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MODERN STEAM GENERATORS

SAFETY ECONOMY

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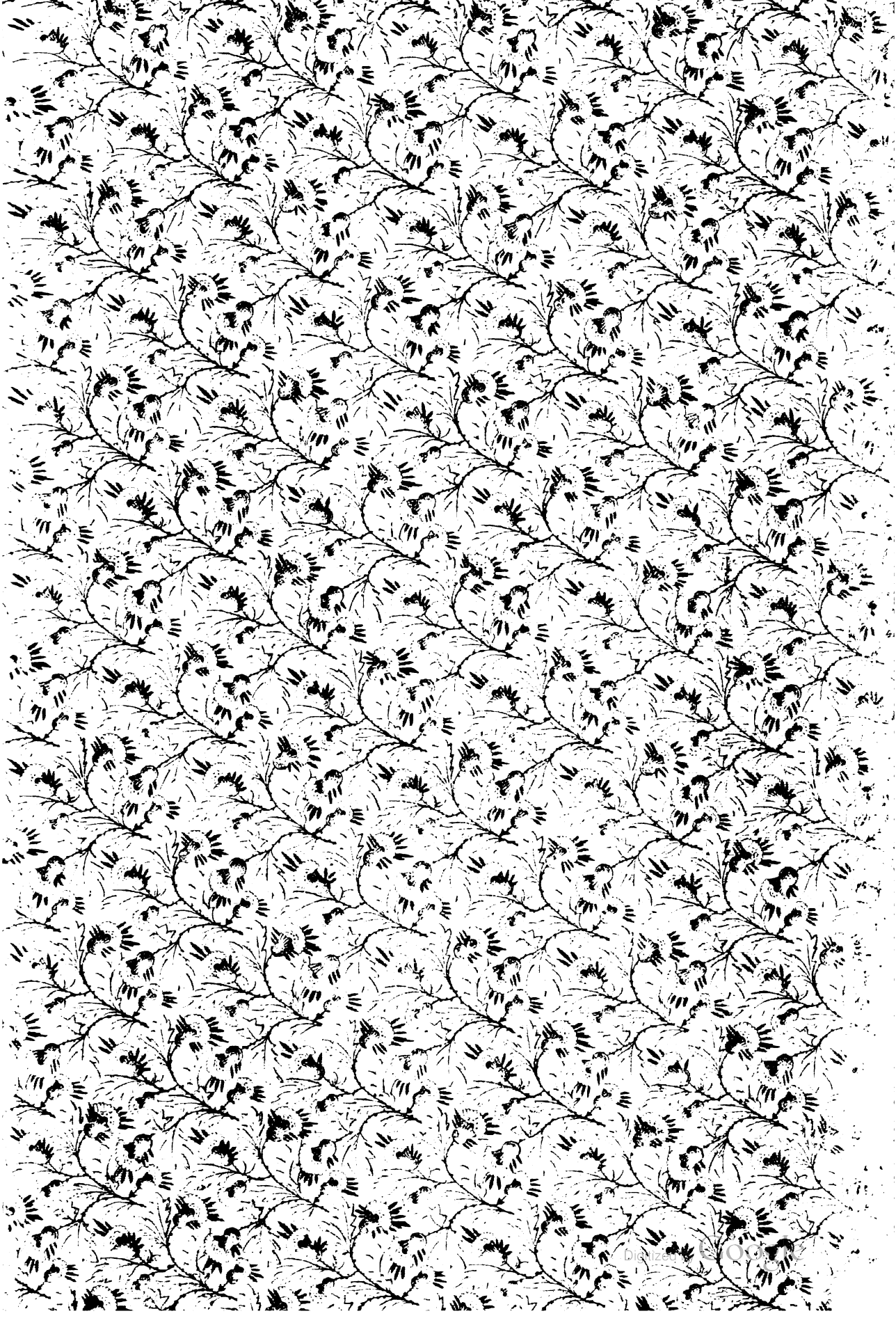

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MODERN

STEAM GENERATORS.

WICKES BROS.,

SAGINAW, MICH.,

U. S. A.

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BIRDS EYE VIEW OF WORKS, LOOKING NORTH.

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Daniel W Mead 20-6
Nov. 1895

Established 1860. Incorporated 1883.

WICKES BROS.,

MANUFACTURERS OF

BOILERS, ENGINES,

AND

HEAVY MILL MACHINERY.

H. D. WICKES, President.
E. N. WICKES, Vice-President.
H. T. WICKES, Secretary and Treasurer.
W. J. WICKES, General Manager.

MAIN OFFICE:
512 NORTH TILDEN STREET.

WORKS:
ON WASHINGTON AVENUE AND TILDEN STREET,
Between Carroll and Astor Streets.

SAGINAW, MICHIGAN,
U. S. A.

1895.

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SAGINAW, MICH.

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PREFACE.

IN presenting this Catalogue of our work to our customers and the public, we have endeavored to illustrate a variety of boilers and settings which have been thoroughly tested and found to meet all the requirements of Modern Steam Generators.

We have compiled herein only such engineering matter as pertains to steam boiler practice, together with tables, which, we trust, may be found of value to the business man as well as the engineer.

We beg to acknowledge our obligation to the following authors, whose works we have consulted and drawn from freely:

PROF. R. H. THURSTON,
THOMAS BOX,
KEYSTONE CHEMICAL COMPANY,
THORP'S CHEMICAL DICTIONARY,
D. K. CLARK,
PROF. R. C. CARPENTER,
GEORGE C. V. HOLMES,
DAVID T. DAY,
F. M. MILLS,
CROOKES & ROHRIG,
TRANSACTIONS AMERICAN SOCIETY MECHANICAL ENGINEERS,
SCIENTIFIC AMERICAN SUPPLEMENT.

We feel confident that first cost is not a matter for primary consideration in the purchase of a power plant, neither do we believe it necessary to charge exorbitant prices because we are turning out the best of work, but to all who are interested in the search for a safe and economical steam plant at a fair price, this volume is respectfully submitted.

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BIRDS EYE VIEW OF WORKS, LOOKING SOUTH.

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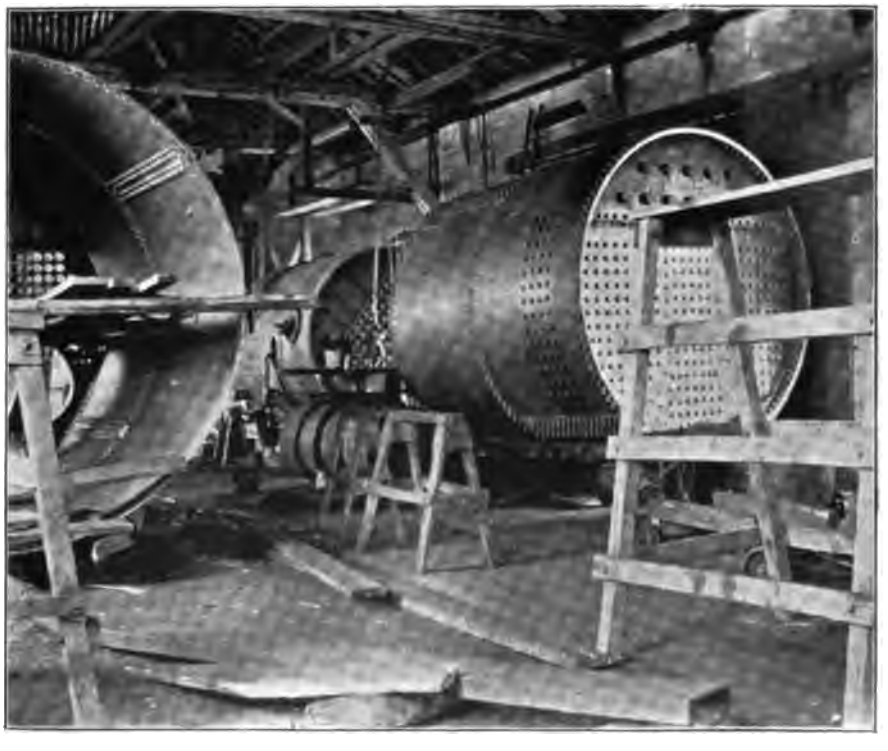
OUR SHOP AND ITS FACILITIES.

WICKES BROS., the present incorporated company, was established in July, 1860, upon the east banks of the Saginaw river at Saginaw, Michigan, under the firm name of H. W. Wood & Co., and the property where now stands an enterprise, the whir of whose wheels and sound of whose hammers are heard for squares around, was cleared of its timber by these pioneers. In 1869 the firm name was changed to Wickes Bros., Mr. Wood having been bought out by the other partners. In August, 1883, articles of incorporation were taken out in the State of Michigan under the firm name, the pioneers, Mr. H. D. Wickes and Mr. E. N. Wickes becoming President and Vice-President respectively, Mr. H. T. Wickes, Secretary and Treasurer, and Mr. W. J. Wickes, General Manager, of the Company as it now stands today. The present manufacturing plant of the Company is partially bounded by the Saginaw river, Tilden street, Washington avenue and Astor street, covering a territory of four city blocks, 300 feet by 300 feet each, besides having a dock frontage on the Saginaw river of 400 feet, from



INTERIOR BOILER SHOP, WEST WING.

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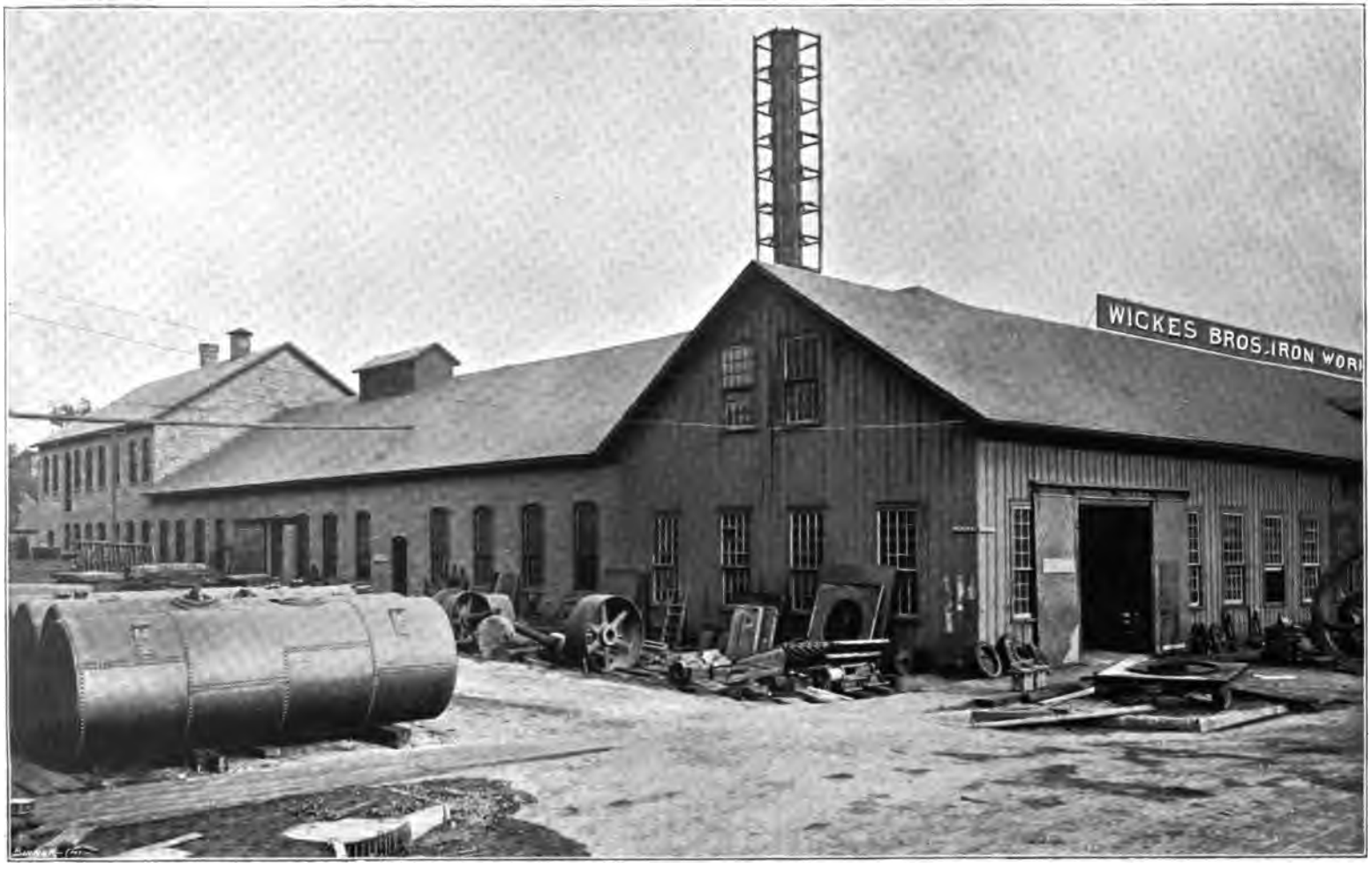

NORTH END OF MACHINE SHOP, LOOKING EAST.

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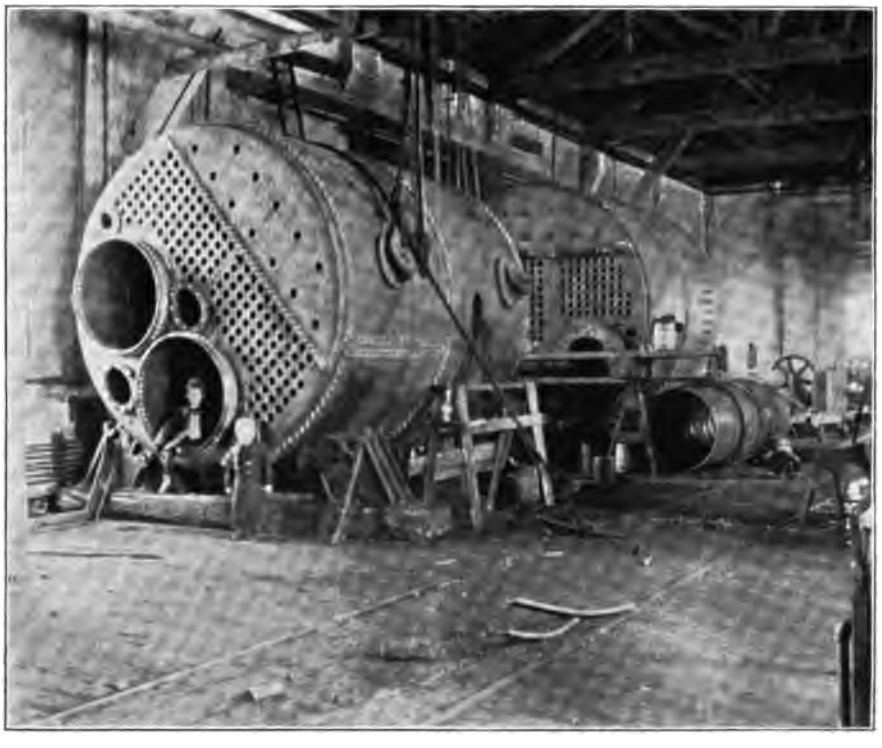
which, via a regular line of boats plying the Saginaw river, bay, and Lake Huron, any port may be covered upon the great lakes. There are two railroad switches running directly into our shops and yards, which connect directly with the Michigan Central Railroad, Chicago & Grand Trunk Railway, and the Flint & Pere Marquette Railroad, thus securing for us unsurpassed shipping facilities to all points.

Our plant, as is seen by the photograph, is divided, for convenience, into a series of shops, there being the Machine Shop, Foundry, Flanging and Blacksmith Shop, Pipe-Cutting Shop, Boiler Shop, Sheet Iron Shop, Pattern Shop and many warehouses.



INTERIOR OF BOILER SHOP, NORTH WING.

The Machine Shop, 200 feet by 175 feet, is equipped throughout with the most modern tools, and is used principally in connection with our large saw mill machinery business. The Foundry, which is 200 feet long and 75 feet wide, is fully up to the present day in its equipment, and is kept busy turning out castings for machine shop and boiler appurtenances.

The Boiler Shop, in whose special interest this catalogue is published, is subdivided into a main and auxiliary shops. The main shop is L shaped, having a total length of 350 feet and is 75 feet wide. The main and auxiliary shops reduced to one building would be equivalent in area to a building 480 feet long and 75 feet wide. These shops are equipped with every possible tool pertaining

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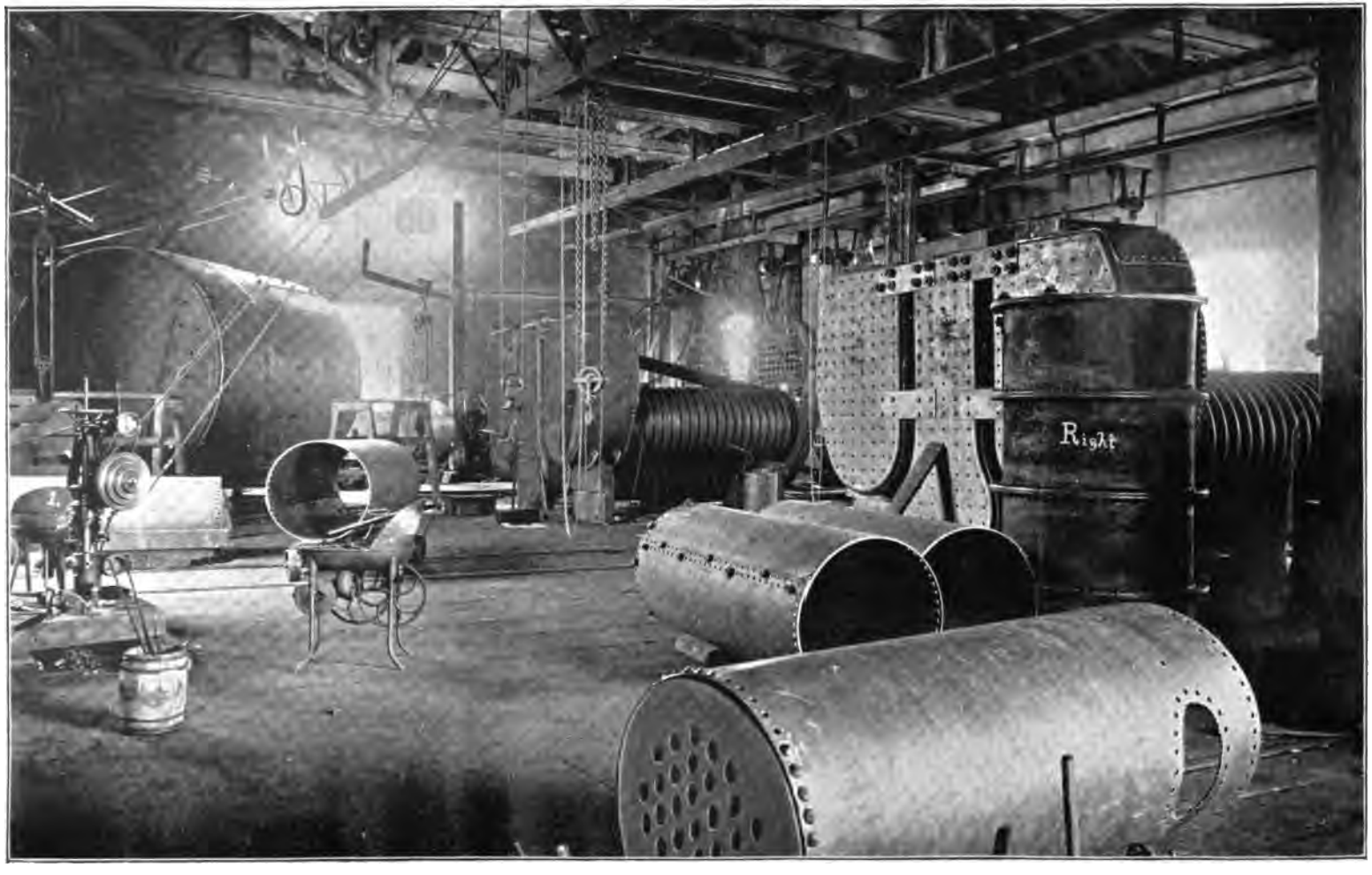

BOILER SHOP INTERIOR, SOUTH WING, SHOWING MARINE WORK UNDER CONSTRUCTION.

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to excellence in boiler-making. Our own pride in giving the highest attainable work not only compels this immense outlay in acquiring tools possessing the highest known mechanical skill and ingenuity, but it has become a necessity for building the hundreds of huge marine boilers that we have, complying with the United States laws and regulations governing this work and subjecting ourselves to the thorough and searching inspection for acceptance of such boilers as is made by the United States Government Marine Inspectors. Such was the rigidity under which we built the boilers for the United States Light Ships, the revenue

ONE OF FOUR U. S. GOVERNMENT LIGHT SHIPS, EACH EQUIPPED WITH TWO 8 FT. X 9 FT. SCOTCH BOILERS, ALLOWED 160 POUNDS PRESSURE.

cutter "William Windom," and others, a partial list of which appears elsewhere. This is the class of work which we turn out, and it will be interesting to engineers and those familiar with tools and workmanship to follow through the various tools in our shops, where from 250 to 300 workmen are continually employed.

All necessary punching is done on a large power punching machine of our own design and manufacture, having a 42 inch gap, and being capable of punching a hole 1⅛ inch diameter through 1¼ inch plate. There are also several smaller punching machines for lighter work. Heavy work is all handled by our own design and make of traveling crane, which has a capacity of 40 tons, while a second crane, for lighter work, is located in the annex boiler shop, having a

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capacity of 20 tons. All marine, government, water tube, high pressure tubular work and other work, when desired, have all the holes drilled upon our upright Dallet Patent Power Multiple Drilling Machine, by which three holes are drilled at one time without shifting the work. Besides this machine there are several radial and suspension drilling machines for drilling tube holes in heads and other work.

All material is carefully planed on a Hilles & Jones latest and largest size plate planing machine, which clamps the plate on a level table and planes it to a true bevel for calking, at both the forward and backward movement of the tool post.

MACHINE SHOP INTERIOR, WEST WING.

Our shop is supplied with several sets of rolls of our own design and manufacture. The largest, in the sense of doing the heaviest work, are vertical, as large and heavy plate for our marine work cannot be handled by horizontal rolls, and keep the plate in a true circle. These rolls are 10 feet high, are driven by double independent engines, and have a capacity of bending marine plate 10 feet wide up to 2 inches thick; and while it has not been necessary to test it to its ultimate capacity, we have frequently rolled on this machine plate 1⅜ inch thick with perfect results. We have also horizontal rolls, driven by independent engines, for bending plate 18 feet and 12 feet long, the 18-foot roll having a

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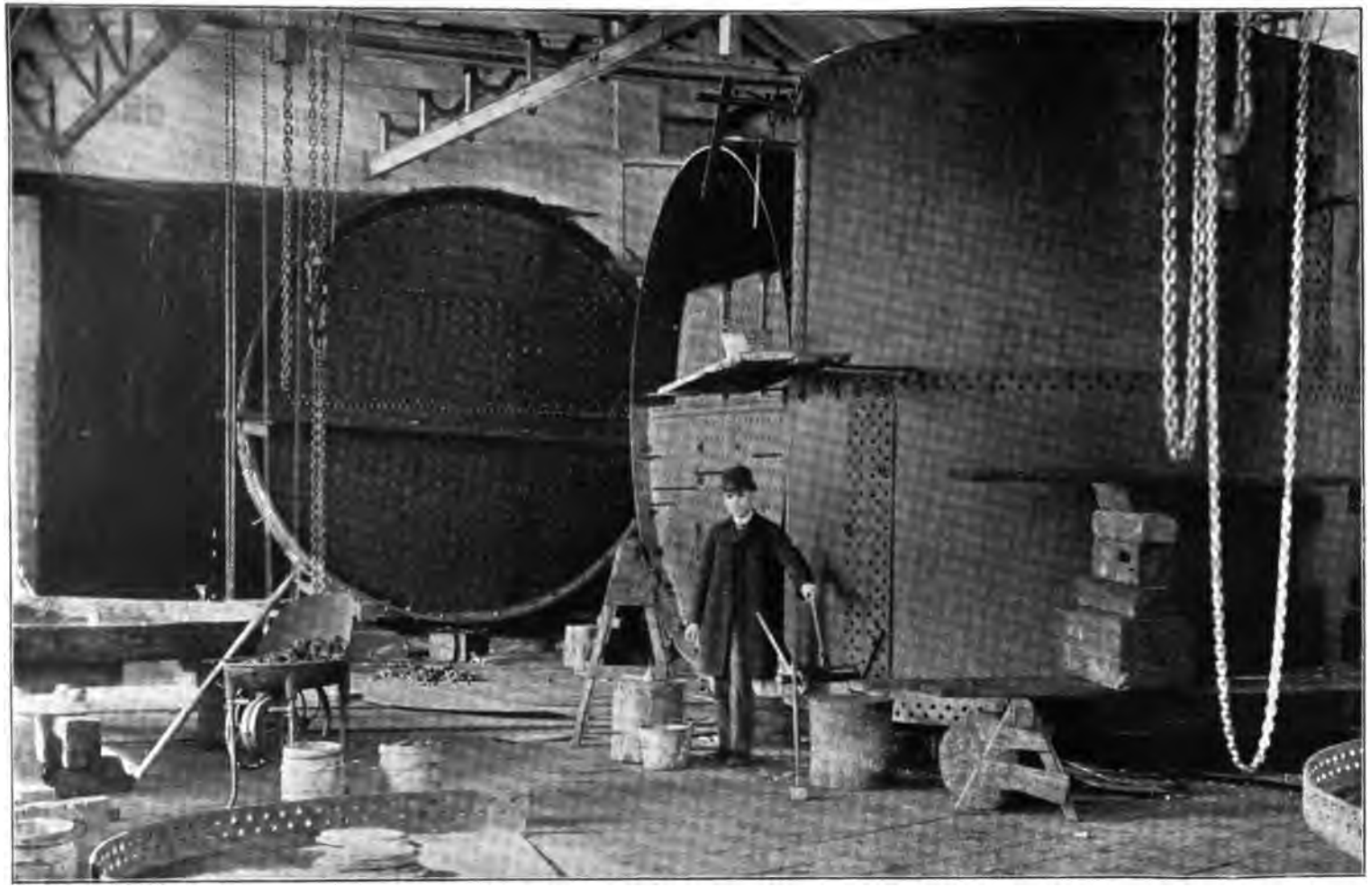

BOILER WORKS INTERIOR, MARINE DEPARTMENT.

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capacity of plate, 18 feet long and ¾ of an inch thick, while we use the 12-foot set for light plate and sheet iron of that length.

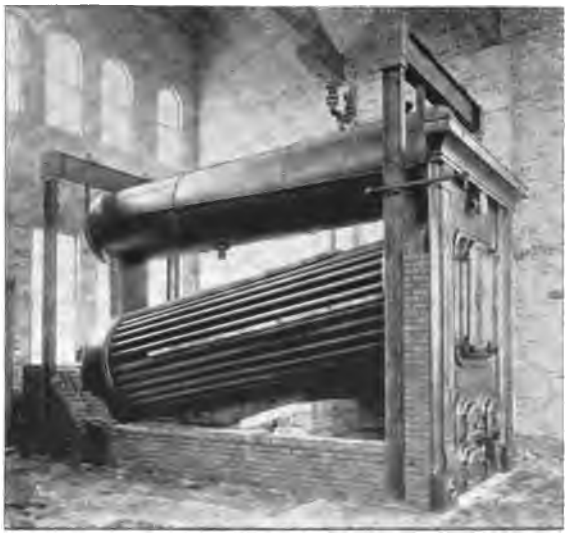
All riveting is done on our hydraulic riveting machine, with patent plate-closing device, manufactured by Bement, Miles & Co. This machine has 10-foot gap, and is a 100-ton riveter. We also use a portable hydraulic riveting machine which is a 100-ton machine of our own design and manufacture. It is handled by a crane also of our own special make.

All flanging and bending of plate is done with our own design and manufacture of machine.

All calking is done with a pneumatic calking machine, which ensures using a round-nosed tool. All tubes are expanded in place with a Dudgeon or roller expander.

The shop is also equipped with large shears, which will cut plate to a maximum of 1¼ inches thick. The shop is fully equipped with all the smaller tools and accessories which are necessary for the class of work which we turn out.

We lay emphatic stress on our marine work, as there is no class of boiler work which taxes the ingenuity and skill of the men, as well as the machinery, as marine boiler making. This same skill and nicety of adjustment of tools is employed in all of our work, and we invite and desire the most searching inspection.



PERSPECTIVE VIEW SHOWING BOILER UNDER ERECTION.

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SELECTION OF A BOILER.

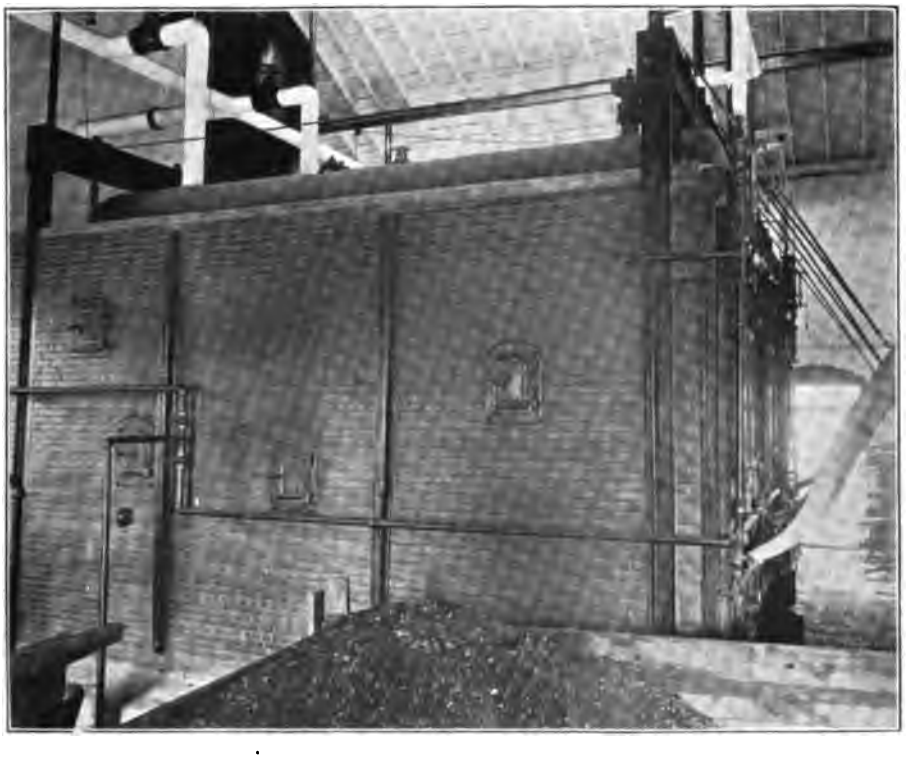
THE improving thermodynamic conditions which have brought the steam engine up to its present nearly ideal condition have been made possible by the continued rise in the ratio of expansion of from unity, in Watt's earliest form, up to twenty and more in our latest multiple expansion engines.

Why High Pressure.

The most essential element in this progress has been the gradual elevation of steam pressure, so that the gain in engine economy might well be termed a growth of steam pressure, or the progress of boiler-making.

Now that high pressure has become the universal standard for steam plants, involving considerable power, and especially where multiple cylinder engines are used in such plants, it is a great mistake to endeavor to use the ordinary horizontal return tubular boiler, and water tube boilers only can fulfill all conditions satisfactorily under such circumstances.

Because horizontal tubular boilers have been and are still so universally used for pressure lower than 100 lbs., and have given good results, it does not stand to reason that their use should be continued for higher pressures.



SIDE VIEW OF 200 H. P. WOOD WATER TUBE BOILER.
SHOWING LOCATION OF SIDE CLEANING DOORS AND PNEUMATIC SHAVING FEEDERS, AS USED AT SAGINAW MANUFACTURING COMPANY, SAGINAW, MICH.

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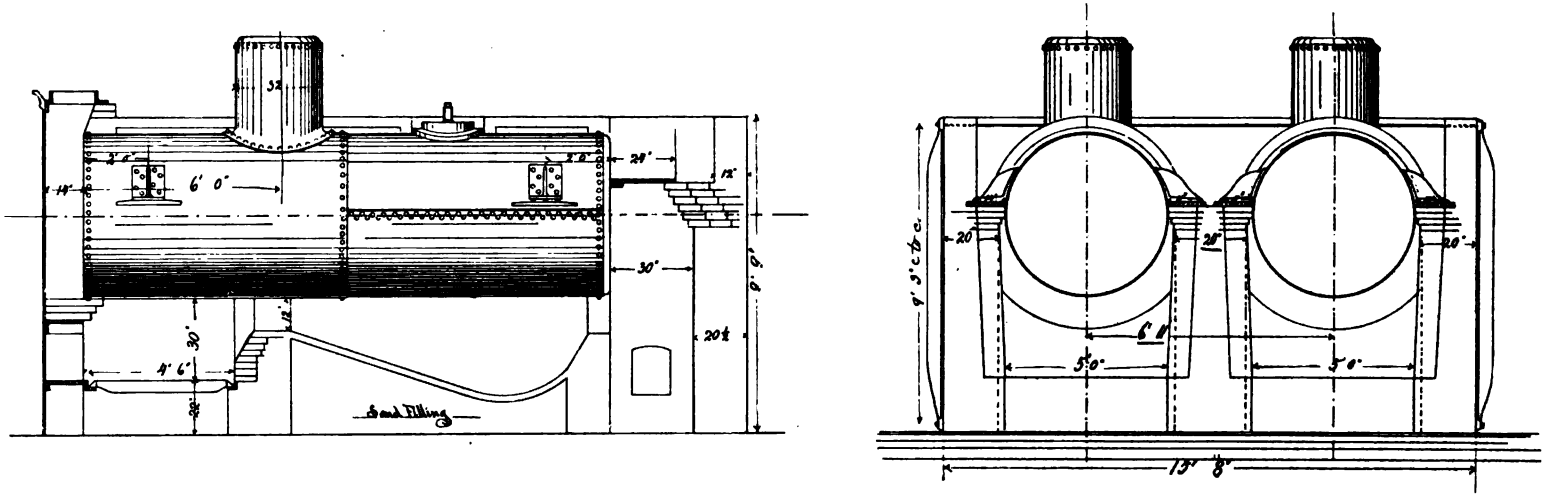

DRAWING.

Setting of Horizontal Tubular Boilers with Full Fronts.

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It is the old story of extra heavy shells subjected to the severe strains of unequal expansion and contraction, a great loss of heat in its conveyance through the shell to the water, and consequent lower economy. The outside of the shell, since fired externally, is apt to become severely burned, with such heavy sheets, especially if a small deposit of scale be present, as is frequently the case. A boiler of such a type, for pressure above 120 lbs., is always a menace to the surrounding property and life, and should never be considered by parties interested in the best results to be obtained, both from an engineer's standpoint and that of the best practical experience.

Decline of Tubular Boilers.

There are still several large stations using horizontal tubular boilers upon which steam pressures are carried up to 130 lbs., but there are many instances of such boilers exploding, doing terrible damage.

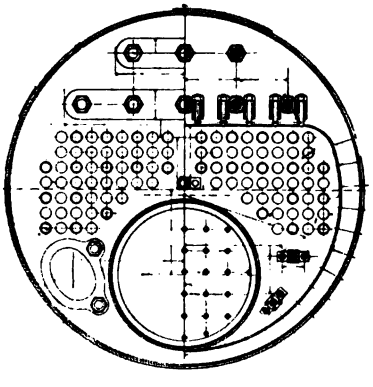
Another detriment is the fact that such steam pressures are only allowable when the boilers are new and for the first three or five years, depending on the care given them. After that time, the pressure is reduced from time to time to a safe working pressure, by the insurance companies, due principally to deterioration of the material, which is caused by corrosion, expansion and contraction, as well as many other effects of a damaging nature.

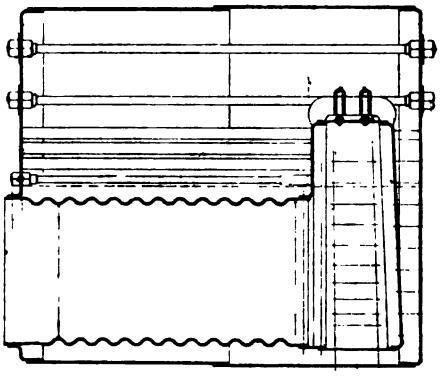
Such reductions of pressure mean lengthened cut-off in engines, which, in turn, means very rapidly reduced economy and efficiency.

Where Tubular can be used.

We are still building horizontal tubular boilers, making them as perfect as the most modern tools and highest attainable skill will allow, but we do not advocate their use except where low pressures are desired.

From the standpoint of safety, water tube boilers made their appearance years ago, and the records of inventions in that line fill many pages in the Patent Office statistics. As high pressures became universal, changes in design were also necessary; still, many types were suitable for carrying with safety high pressures, and these types alone have survived during the years of progress in steam engineering. A very common and well-known type is that employing cast iron headers





DRAWING.

Scotch Marine, with Single Corrugated Furnace. No Dome.

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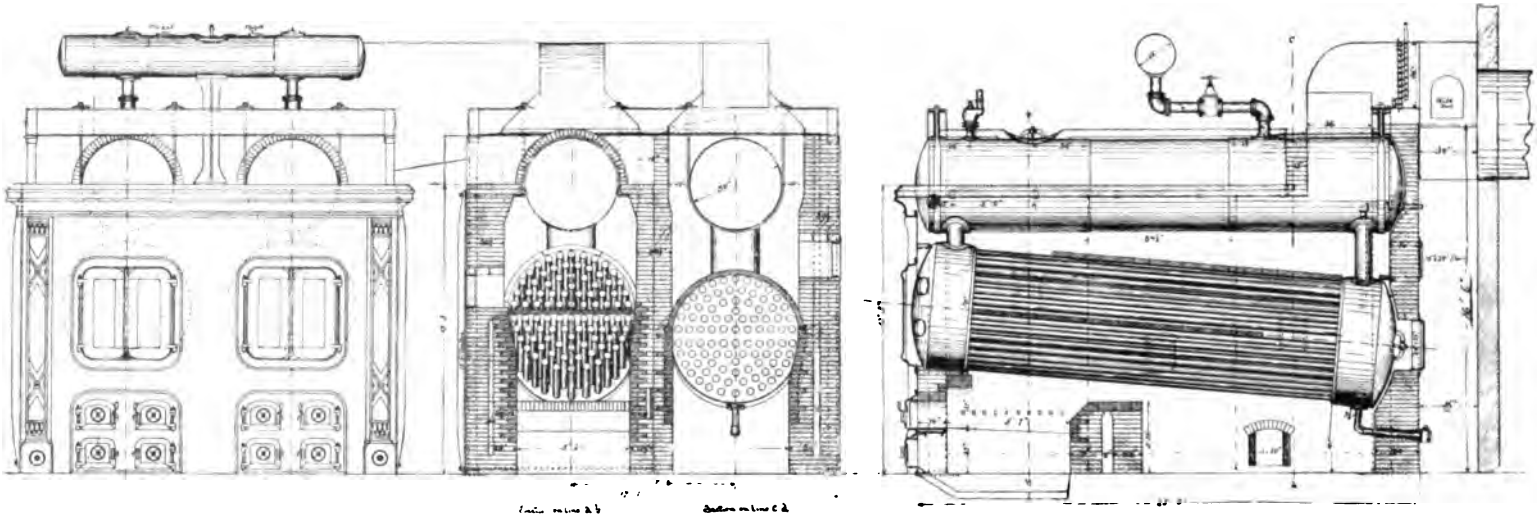

DRAWING.

Showing Setting of 150 H. P. Wood Water Tube Boilers with ordinary Coal Burning Furnace, as set for City Water Works, Dayton, Ohio.

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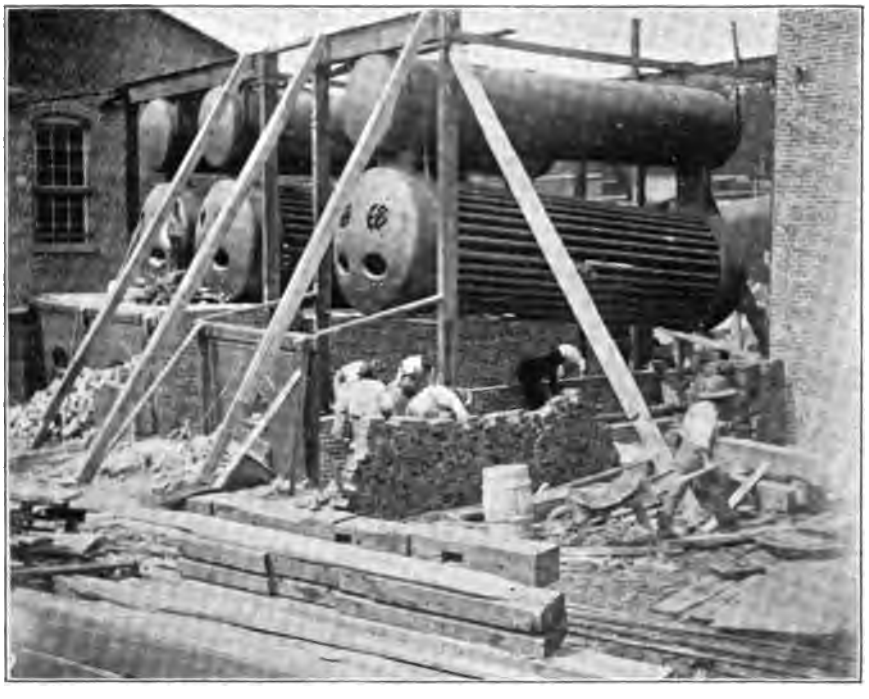
bolted or riveted on the ends of one or more steam drums, and the tubes, expanded into these headers, and extending longitudinally over the grates are inclining at an angle of 15°. The holes in the headers through which these tubes pass are covered and made tight by a hand hole plate and gasket, or a ground joint is made. Frequently defects are found to develop in these cast iron headers and they crack open, causing heavy repairs and serious delays. Another gross error in this design of boiler is the fact that they expect the water and steam to pass from a series of tubes into the drum through one tube of the same size as each in the series. This is a vital point, for it is readily seen that the circulation of water



ERECTING THREE 200 H. P. WOOD WATER TUBE BOILERS
AT THE PAPER PULP MILLS OF E. C. HARGRAVE & CO., HINCKLEY, N. Y.

must be strangled in such a delivery, and the absence of circulation means the development of undue strains, and therefore large repairs. Those well schooled in boiler work are substituting large and all steel headers in their construction, as well as arranging their delivery pipes from tubes into drums, so that they have an area ample for the rapid and smooth delivery of all the water from tubes to drums.

Proper Water Tube Boilers.

The space occupied by a water tube boiler in comparison with the horizontal tubular can be readily comprehended by the following: If a plant of 1800 horse-power was required and 50 horse-power units used, or 48 inches diameter to allow for 150 lbs. pressure, of the tubular type, it would require 36 boilers, occupying an actual floor space of 4446 square feet, not counting firing space. The water tube

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could easily be utilized in 200 horse-power units, requiring an actual floor space of 2200 square feet.

In the selection of a water tube boiler, know well the reputation and standing of the firm you deal with, deal only with those building their own boiler, in their own shop, thereby securing uniformity and reliability of workmanship and material.

What Boiler to select.

SELECT a boiler which is made entirely of steel, thereby securing absolute safety and immunity from costly delays and repairs.

SELECT a boiler having the least number of joints, especially packed or ground joints, thereby avoiding annoying leaks and "shut downs."

SELECT a boiler which is the most accessible in all its parts, thereby insuring easy, rapid and thorough cleaning.

SELECT a boiler having large delivery ducts from tubes to drums, thereby insuring thorough, rapid and smooth circulation, which aids in avoiding the accumulation of scale.

SELECT a boiler having nothing but straight tubes, thereby enabling the engineer to look through them for examination and scrape them when dirty.

We have had the importance of all the above points clearly in mind while designing the **Wood Boiler,** and we invite the public's thorough examination from every standpoint.

ANNEX POWER PLANT OF MORGAN & WRIGHT, CHICAGO.
WOOD WATER TUBE BOILERS SET WITH MURPHY AUTOMATIC STOKERS.

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WOOD'S PATENT WATER TUBE SAFETY BOILER.

DESCRIPTION, CONSTRUCTION, SUPPORTS, FRONTS AND FITTINGS, FURNACE, SAFETY, ECONOMY, DURABILITY, ACCESSIBILITY.

DESCRIPTION OF BOILERS.

The Wood Patent Water Tube Boiler, as built by us, consists of two cylinders, designated from their use as "tube cylinders." Into one end of these cylinders, called the tube sheet, the tubes are placed in a staggered position for the purpose of insuring a perfect surrounding by the heat. In the other end of the tube cylinders, being a convex head, are placed large manholes, four in the front tube cylinder, one in the rear, whereby easy and quick access may be had to all the tubes, which are perfectly straight and may readily be examined or cleaned through their entire length. Above, and connected to each of the tube cylinders by elliptical necks, is the drum. The rear neck being longer than the forward and of such a length that when the boiler is supported in place, the drum is pitched about one-half inch to the foot, which gives the tube cylinders and tubes a pitch of two inches to the foot. This method at once promotes in a mechanical sense the circulation of the water, due primarily to the difference between the initial and final temperature of the products of combustion.

Efficiency of Circulation.

By the use of fire brick tile the boiler is divided into three compartments, which gives to the products of combustion three longitudinal sweeps through the entire length of the boiler. This method of surrounding the entire tube with heat, and then conducting it through the entire length, is acknowledged by engineers to insure a much more perfect absorption of heat than by any right-angled or transverse impingement of heat, that might be employed. Added to the gain of absorption by our method of conducting the heat currents is the increased absorption which is easily seen to result from passing the products of combustion three times the total length of the boiler. This, of necessity, means low waste temperatures and therefore high efficiency.

Efficiency of Heating Surface.

The water line of the boiler is the horizontal mean center line of the drum, but owing to the slant of the drum, the water is lower in front than at rear. This, as is seen at once, gives a very large disengaging surface for the steam, especially in front, at which point, by means of a dry pipe, the steam is taken from the boiler. This large disengaging and separating surface is one of the prime causes of constant delivery of dry steam, so notable a point in the **Wood Boiler**. At the rear of drum is the surface blow-off, from which any deposits in mechanical suspension with the water may be blown off and removed. At the bottom of the rear tube cylinder, being the lowest point and not directly touched by the heat of combustion, is located the large blow-off, from whence all impurities passing the

Why Steam is Dry.

How Blown Out.

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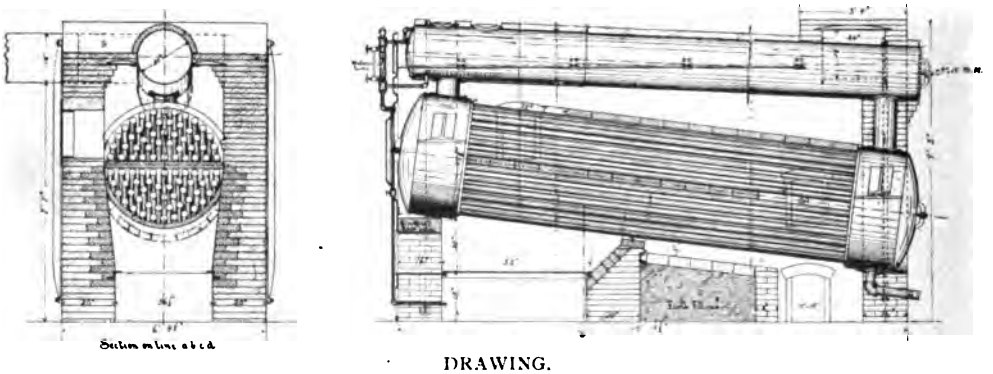
surface blow-off may be drawn out of the boiler, since they are deposited at this point in obedience to the laws governing our thorough and constant circulation of the water.

The feed water pipe is passed into these boilers through the rear or front head of drum, from whence the pipe is dropped down through the rear neck into the tube cylinder, at which point the feed water delivery is made in a downward direction, and in coincidence with the direction of the currents of circulation, whose rapidity of motion are induced by the strong downward action of the feed water when leaving the delivery pipe.

CONSTRUCTION.

THE **Wood Patent Water Tube Safety Steam Boiler,** (as built by us), is made of the best open-hearth flange steel, of from 55,000 to 60,000 pounds tensile strength. The "Tube Cylinders" have a range in diameter from 36 inches to 84 inches, and the thickness of plate employed varies from $\frac{5}{16}$ inch to ¾ inch, according to the size of boiler desired. The shell plates of the tube cylinder are about 20 inches long, and are rolled in shape from one continuous plate; the rivet holes are all drilled, the form of joint being laid out in strict conformity with the United States laws and regulations pertaining to marine work, while the riveting throughout is hydraulic riveting, using Burden rivets, and placing thereon a pressure varying from 50 to 100 tons, according to requirements for tight and perfect joints. There are two tube cylinders to each boiler, one front and one rear, they being duplicates save in the number of manholes. The inner or tube heads are made of steel plate, having a range in thickness from ½ inch to ⅞ inch, and the tube holes are all carefully laid out in level horizontal rows and staggered vertical rows, when they are all smoothly and truly drilled. The outer heads are dished heads, the radius of the curvature being the diameter of the tube cylinder, the thickness of plate varying from $\frac{7}{16}$ to ¾ inch. The transverse seams of rivets, holding the heads in place, are laid out and built in strict conformity with the United States Marine Laws and Regulations. The dished head of the front tube cylinder is provided

Tube Cylinders.



DRAWING.

Showing arrangement of Drum for adaptability to Minimum Height.

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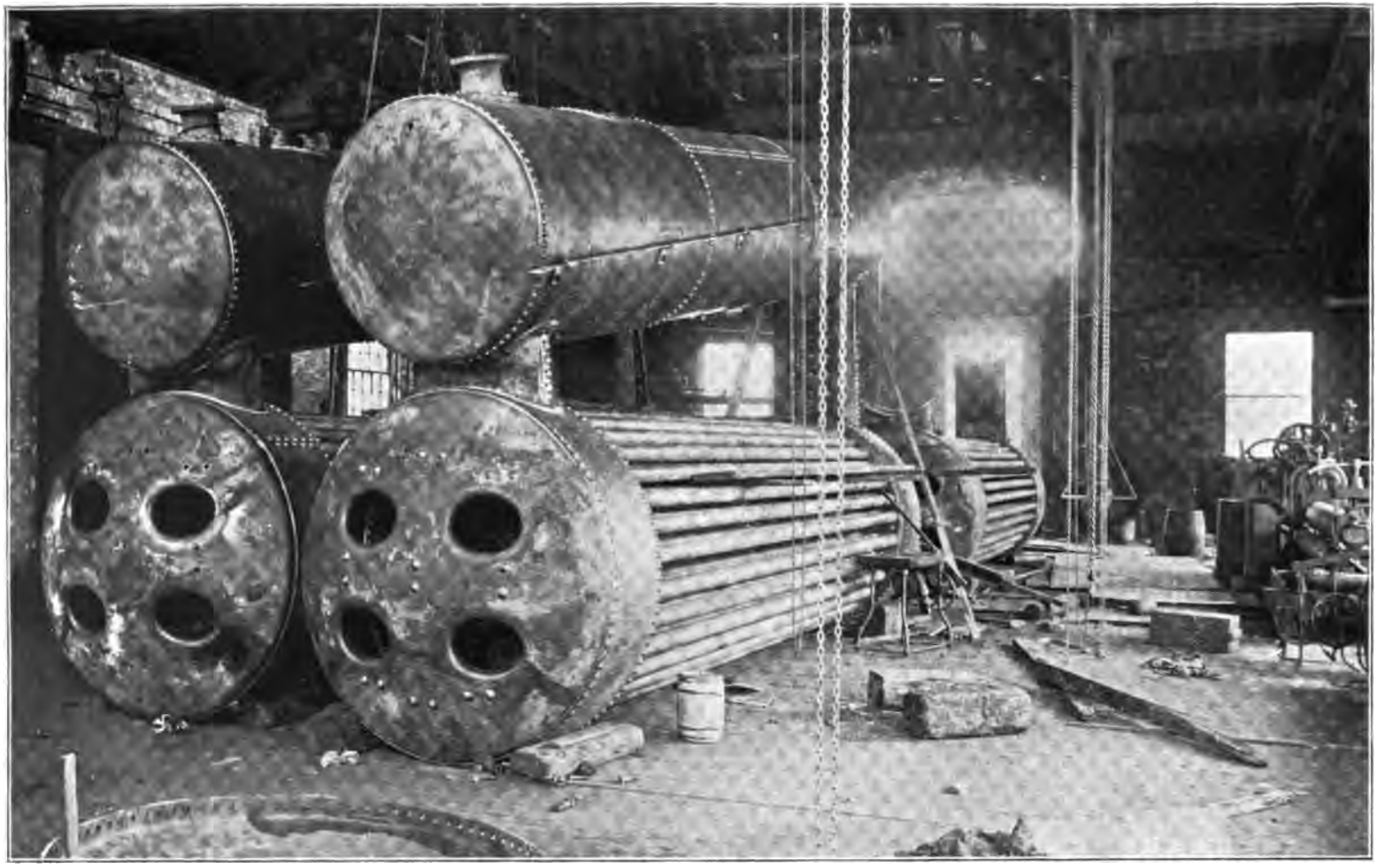

BOILER SHOP INTERIOR, LOOKING EAST, SHOWING WATER TUBE BOILERS IN PROCESS OF CONSTRUCTION.

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with four manholes, in a medium-sized boiler, while the rear tube cylinder is equipped with one. These manholes are 11x15 inches, formed by flanging the plate in, as the Eclipse pattern. The edge of the plate is reinforced, by a ¾-inch ring being shrunk around the turned-in edge. The dished heads are then put into a milling machine and planed, which gives a flat seat or bearing surface 1¼-inch wide for gaskets and steel manhead plates. The tube cylinders contain heavy permanent braces from inside of the tube sheet to inside of dished head, which are carefully designed and constructed, so that an equalization of tension is had at all points. The drums are made of the same material throughout as the tube cylinders, the same care and rules being observed in the designing and construction of joints and braces as exercised in that of the tube cylinders. All plates are carefully rolled of three continuous sheets. The drum is equipped with a manhole of same design as those placed in tube cylinders, and the heads are dished to a radius equal to the diameter of the drum. All the seams in the boiler are calked both inside and out with a round-nosed tool used in our pneumatic calking machine, which ensures perfect joints without detriment to the plate. All bracing is of the "Crowfoot" pattern, and the iron used for this work of the "Ulster brand." The braces are connected together by weldless steel braces, without turnbuckles of any kind, being spaced so that they in no way interfere with the easy movements of a man while in the cylinder. The drum and tube cylinders are connected together by oval necks, constructed of material equal in character to that employed in other parts, and of a thickness equal to that used in the tube sheets. These necks are made of one continuous sheet, are carefully flanged when joined to tube cylinder and drum, and are constructed, both in riveting and bracing, in close conformity to the rules applied to the other work. The tubes used are the best lap-welded charcoal iron tubes, 4½ inches external diameter for the lower tier, and 4 inches external diameter for the upper tier. The tube cylinders are connected together by these tubes, which are first carefully expanded in place with a roller expander, and then thoroughly beaded down on the tube sheet, thus ensuring a tight and perfect tube connection.

Manhole.

The Drum.

The Necks.

Tubes.

Baffle Plate and Dry Pipe. The drum is equipped with a baffle plate near water line, extending from front head over forward neck for a distance of about 5 feet, which directs the flow of circulating water toward the rear of boiler and prevents the rising of slugs of water into the perforated dry pipe, suspended directly overhead, through which steam is taken away from the boiler. All the necessary flanges are of steel, and are first fitted carefully to the part where they are riveted. The fire tile which directs the passage of the heat of combustion are manufactured especially for us from the very best quality of fire clay. The tile which divide the tubes into the upper and lower tiers are flat, and are placed between the tubes, starting from the forward tube cylinder and extending back to from 36 inches to 48 inches of the rear tube cylinder. Above the tubes are placed circular tiling of the radius of tube cylinder, which extend

Tile.

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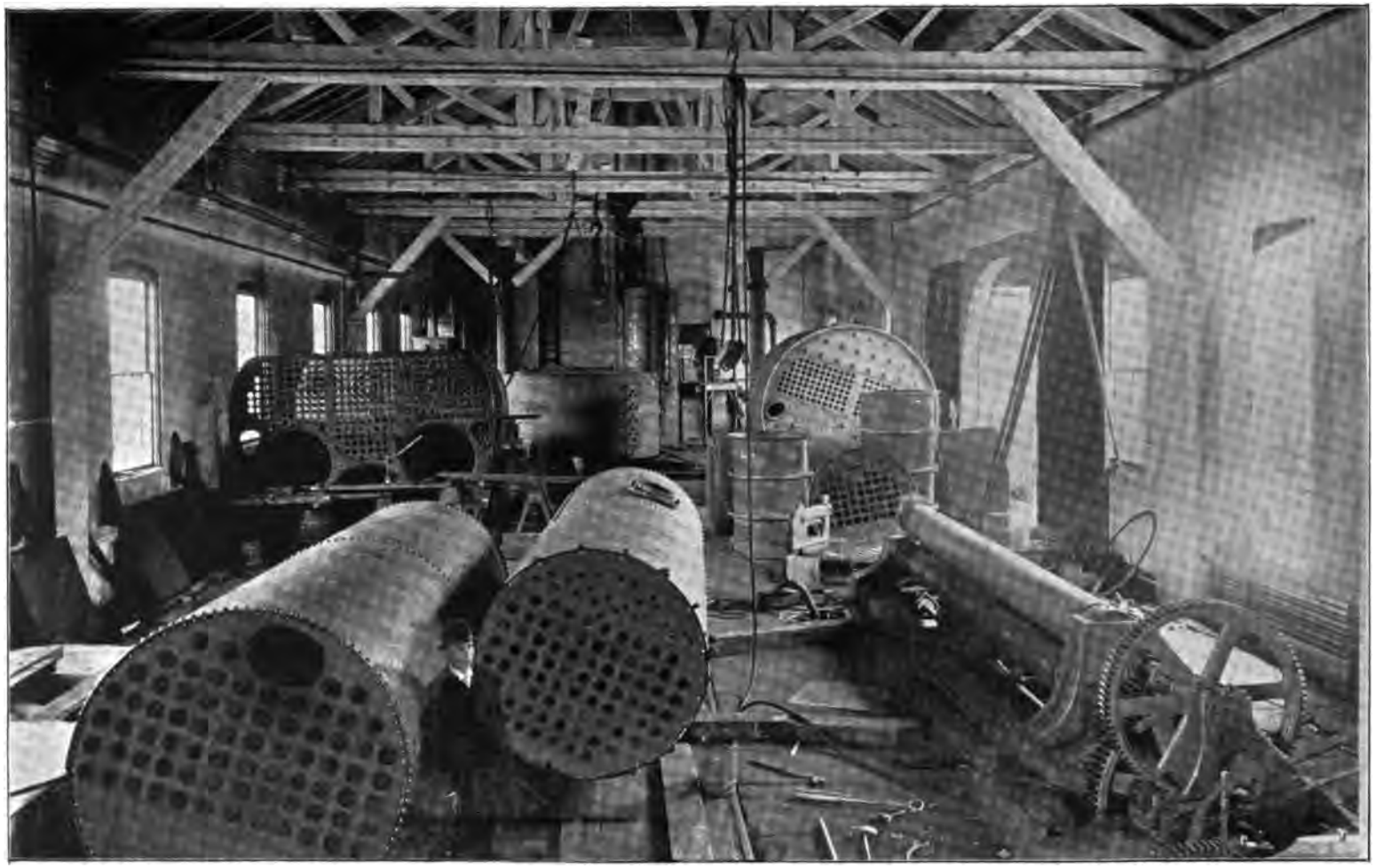

BOILER SHOP INTERIOR, LOOKING NORTH TOWARD HYDRAULIC RIVETTING MACHINE.

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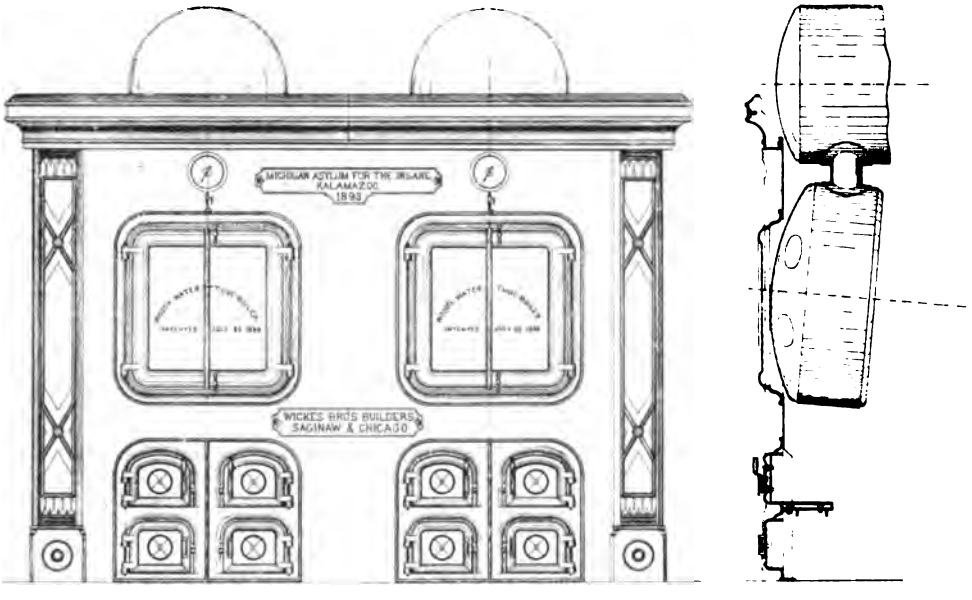
from rear tube cylinder forward to within 36 inches to 40 inches of the front tube cylinder. Throughout all our work the most modern practice is adopted in design and the highest attainable skill is used in the workmanship, thereby securing the closest approximation to perfection.

SUPPORTS, FRONTS AND FITTINGS.

SUPPORTS. Our boiler is suspended, both front and rear, by a heavy band of steel of U form passing under the drum at both ends, the drum resting easily in the cup of the U, while the terminals, drawn out to a circular section and threaded, are carried up between two channel beams, located above the boiler, where they are secured by large washers resting on top of the channel beams and



DRAWING.

Wood Water Tube Steel Body Front.

held in place by a heavy nut placed on the end of the U terminals. The channel beams are supported by steel I beam columns resting upon a heavy cast-iron base, well secured to the foundation. It will be seen by this method we provide at once a simple and easy means for allowing the boiler to adjust itself to any change of length or condition that the differences of temperature may impose upon it. Further than this, we provide for the change independently of the brick setting or front, which have simply their own weight to take care of, and will, therefore, not become cracked, distorted, or out of line.

THE FRONTS, as now built, are neat and ornamental in design. The body is ade of steel plate, trimmed with a cast-iron cornice, ornamental columns, door

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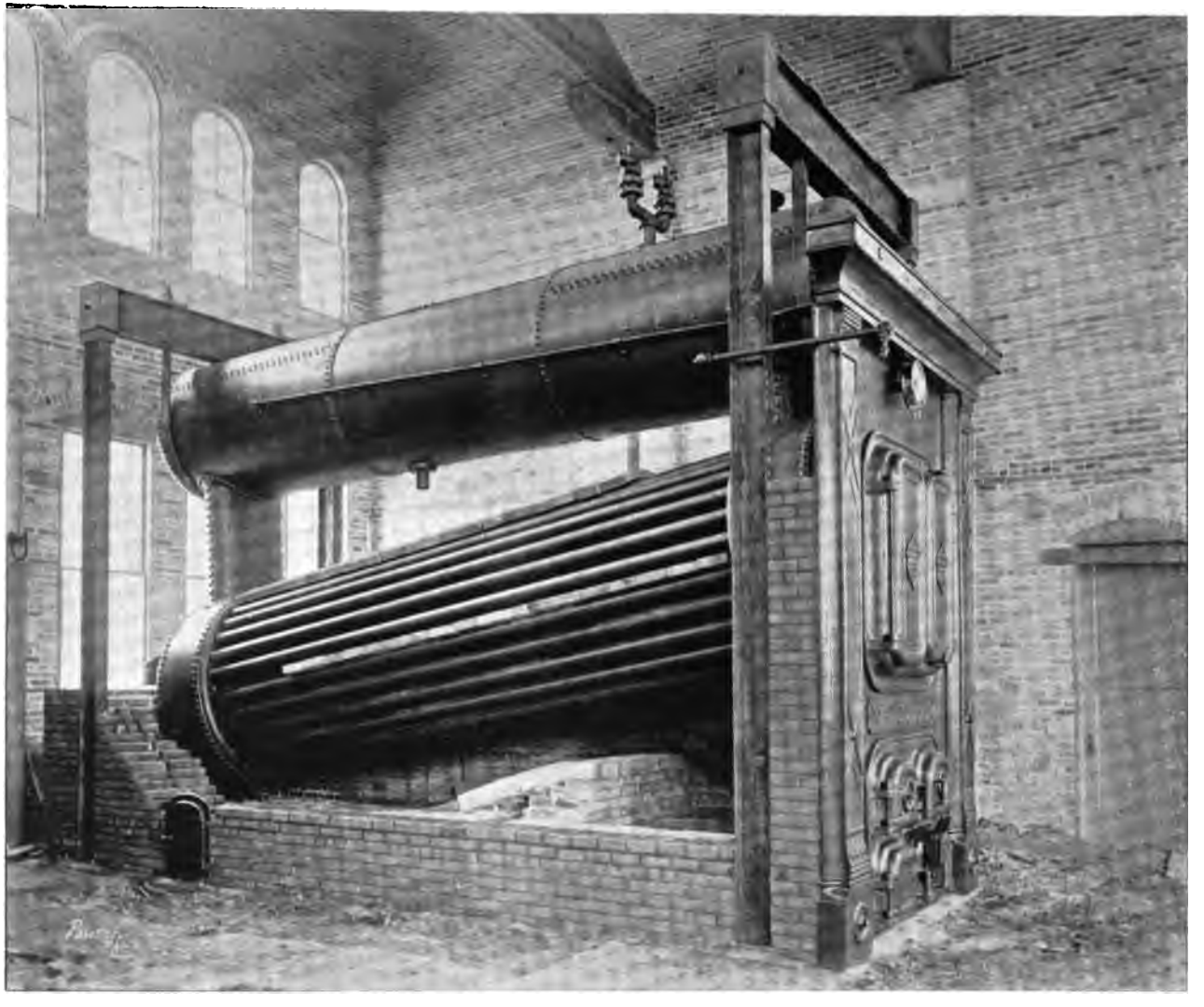

VIEW OF ONE BOILER WHILE BEING ERECTED FOR THE UNION STREET RAILWAY COMPANY, SAGINAW MICH.
SHOWING METHOD OF TILING AND MANNER OF SUSPENSION.

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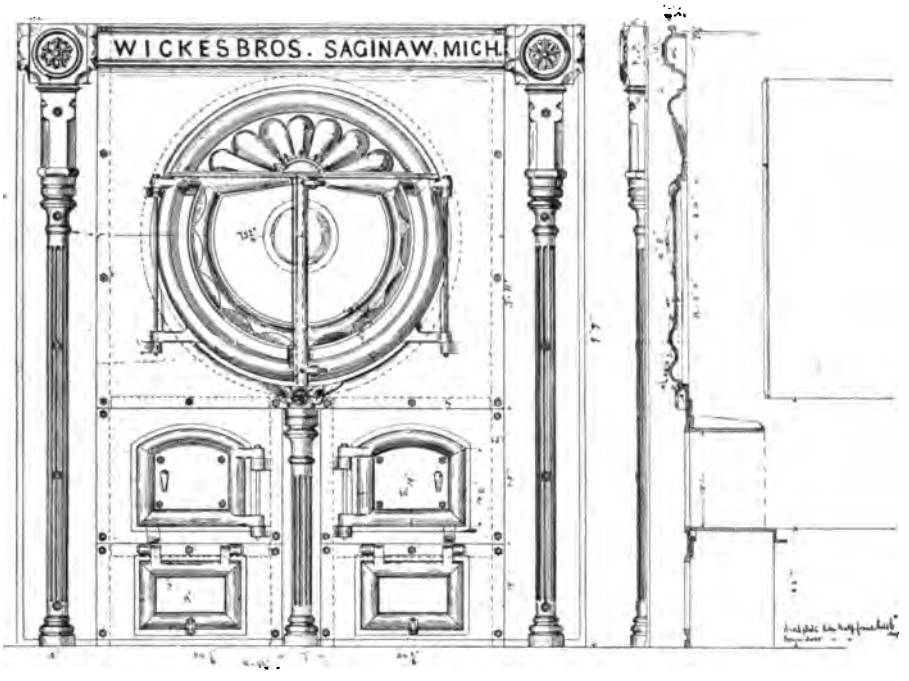
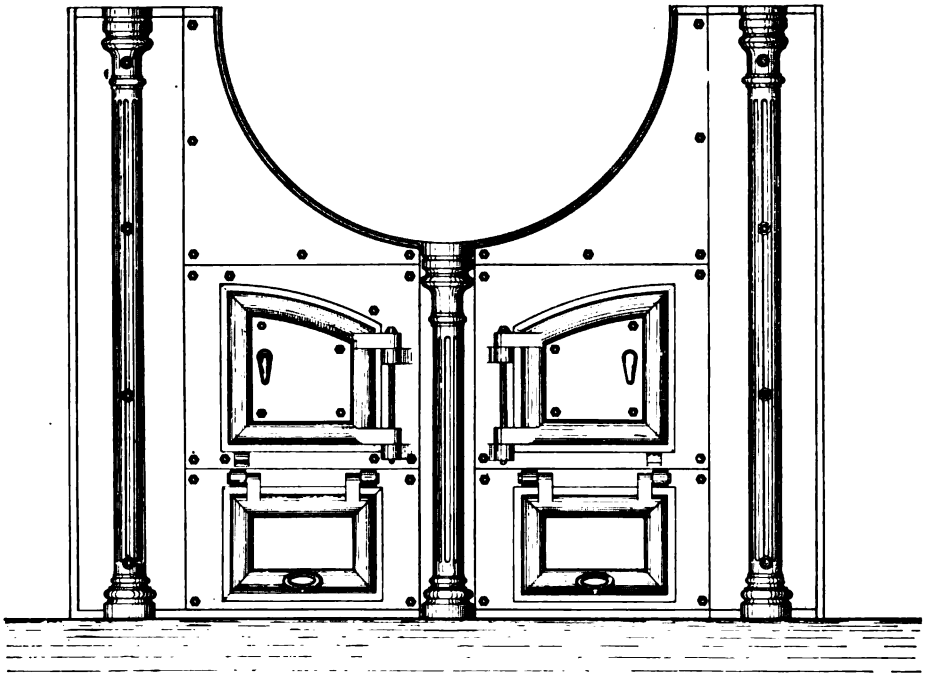


DRAWING.

Full Front Horizontal Tubular Boiler.



DRAWING.

Half Front for Horizontal Tubular Boiler.

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frames, doors and name plates. The body being of steel, they never crack or warp out of shape, and when painted present a smooth and finished appearance not attainable by the use of cast-iron bodies.

THE DOORS AND FRAMES are carefully planed, so that when closed all joints will be air-tight and perfect. The fire-doors are equipped with air registers, baffle plates and liners, of a durable character.

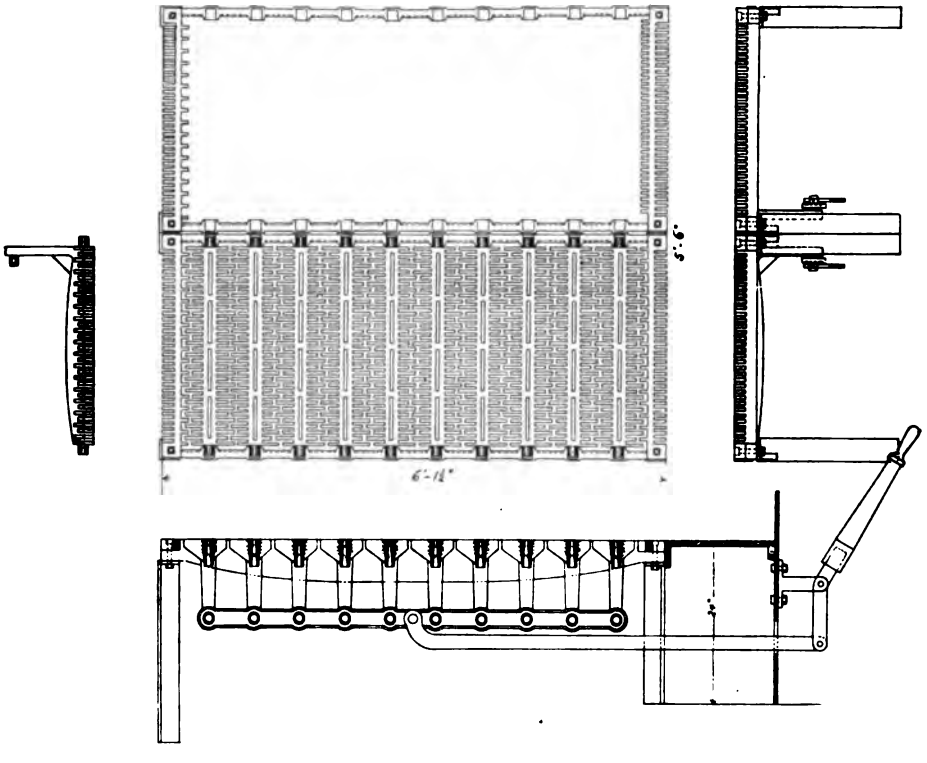
THE FIXTURES consist of a full set of suitable buck stays, side cleaning doors with carefully planed faces and seats, dampers and damper plates.

THE FITTINGS for each boiler consist, according to its size, of one pop safety-valve, one blow-off valve, one globe and check-valve for feed-pipe connections, one 12-inch polished steam-gauge, one large combination water-column, fitted with three gauge-cocks and water-glass complete.

THE PIPE for each boiler shall include that necessary to connect up the trimmings, as enumerated, in the best possible manner, and carry the blow-off and feed-water connections to outside the boiler walls.

THE TOOLS furnished are one flue-scraper, one steam flue-blower with necessary hose, and one steel wrench for manhead nuts.

GRATE BARS. We manufacture a number of different types of grate bars suited for burning various types of fuel and meeting the existing conditions.



DRAWING.

Rocking Grates.

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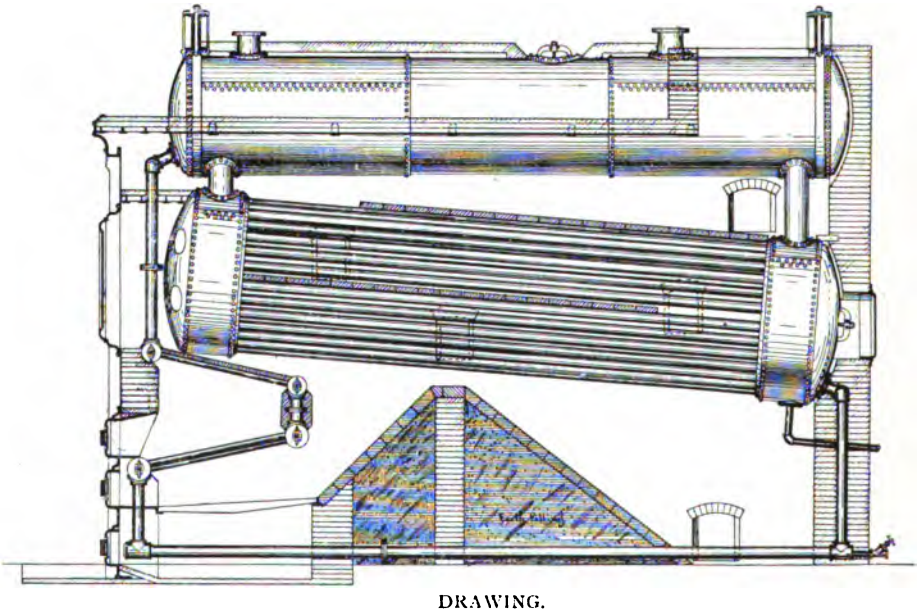
It is our custom to treat each plant as an individual problem in this important branch, advising a type of grate which will be best adapted to the contemplated fuel used, as well as the other existing requirements.

We present cuts showing one form of shaking grate, which we manufacture, and will furnish at the dictation of our customer. All necessary appurtenances for properly equipping and adjusting the grates are included.

FURNACE.

The setting of the **Wood Boiler** is of such design that by furnishing our sectional front it may be adapted easily to Murphy, Hawley, Roney, Brightman, or any of the patent furnaces or mechanical stokers, whose purpose is increased efficiency of combustion, and some of which offer facilities for the application of mechanical coal-conveying and distributing machinery, which has come into



DRAWING.

Showing the Wood Water Tube Boiler equipped with the Hawley Down Draught Furnace.

prominence and favor in plants where a large amount of power is required. The boiler is also well adapted to the application of any kind of oil burner or for natural gas.

Sawdust Burners.

We manufacture and have in operation special furnaces for burning shavings, dry and wet sawdust, together with conveying and distributing apparatus for depositing this fuel directly into the furnace. These furnaces are of the "Dutch oven" pattern, equipped with special grates and air ducts for the admission and distribution of the proper amount of air for thorough and complete combustion. The sawdust from mill saws is very fine, and when coming from certain kinds of timber, such as hemlock and hard wood, it is very

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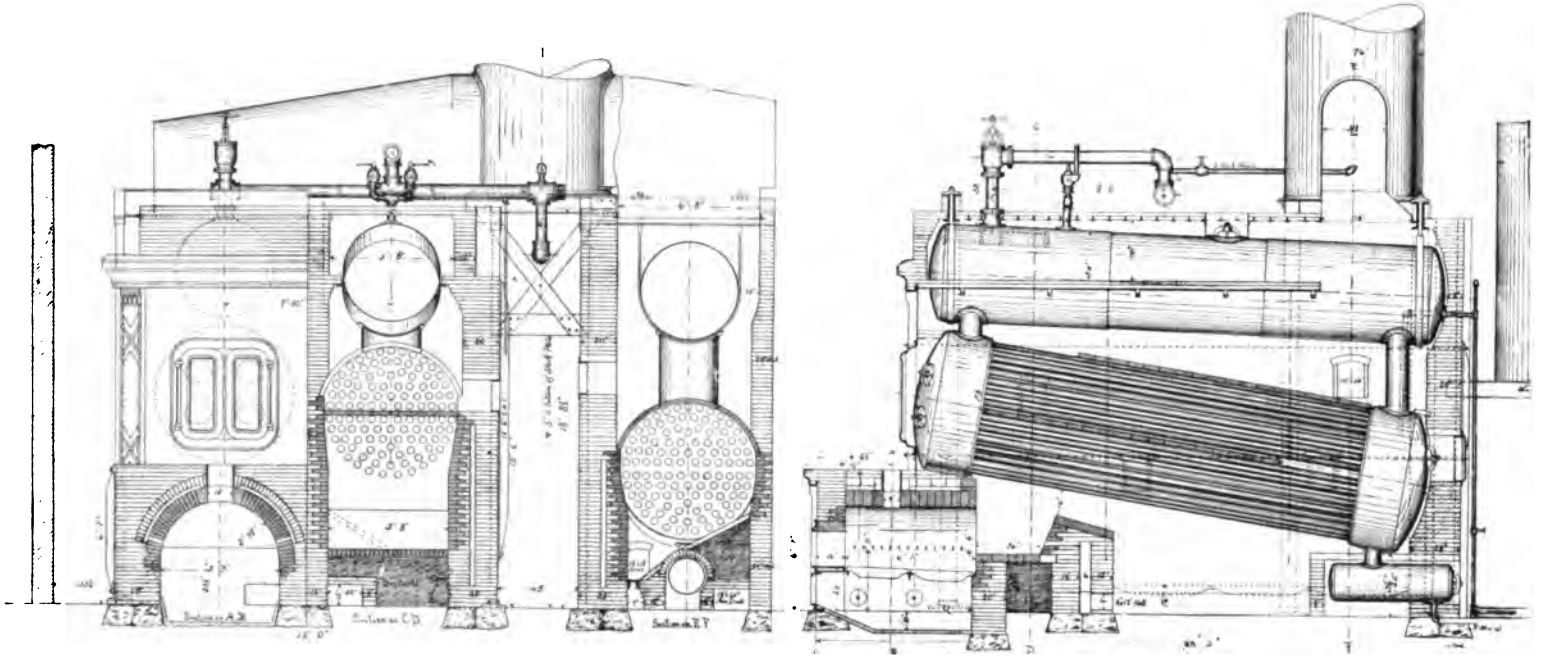

DRAWING.

Showing the Setting of 200 H. P. each Wood Water Tube Boilers. equipped with Furnace for burning Wet Sawdust and Shavings. as built for Eddy Bros., of Bay City, Mich.

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difficult to burn, and the mills using tubular boilers, set in the ordinary way, have to air-dry the slabs from the logs and then use in large quantities to help burn the sawdust, even then experiencing the greatest difficulty. With this setting the sawdust is burned completely, without difficulty, and using no slabs whatever. The furnaces, as shown by cut, are built out in front of the boiler, the shavings or sawdust being fed down through the opening in the arch, in chutes, by gravity. The fire-box, as constructed, consists practically of a brick oven, having a fire-brick lining with no cooling surfaces whatever. The temperature of this oven is so high that the gases distilled from the damp and green fuel are quickly ignited and burn, and this temperature is also so high that there is no smouldering and bedding down of the fuel. After leaving the fire-box proper, the gases pass over a bridge wall and back to the back end of the water-tubes, passing up around them, and thence to the front and then back beneath the steam and water drum to the stack. This course is readily traced from the engraving. The combustion chamber back of the brick wall is of V shape, so that all accumulations, ash and soot are very readily removed and spaces kept clean. These furnaces are the only correct type used for the economical and efficient handling of this special type of fuel, and we recommend their use to all contemplating using this class of fuel. Furnaces of this type may be seen in operation at the following well-known mills: Cummer & Diggins, Cadillac, Mich.; Eddy Bros., Bay City, Mich.; C. K. Eddy & Sons, Saginaw, Mich.

SAW MILL PLANT OF C. K. EDDY & SONS, SAGINAW, MICH.
SUPPLIED WITH FOUR 200 H. P. EACH WOOD WATER TUBE BOILERS.

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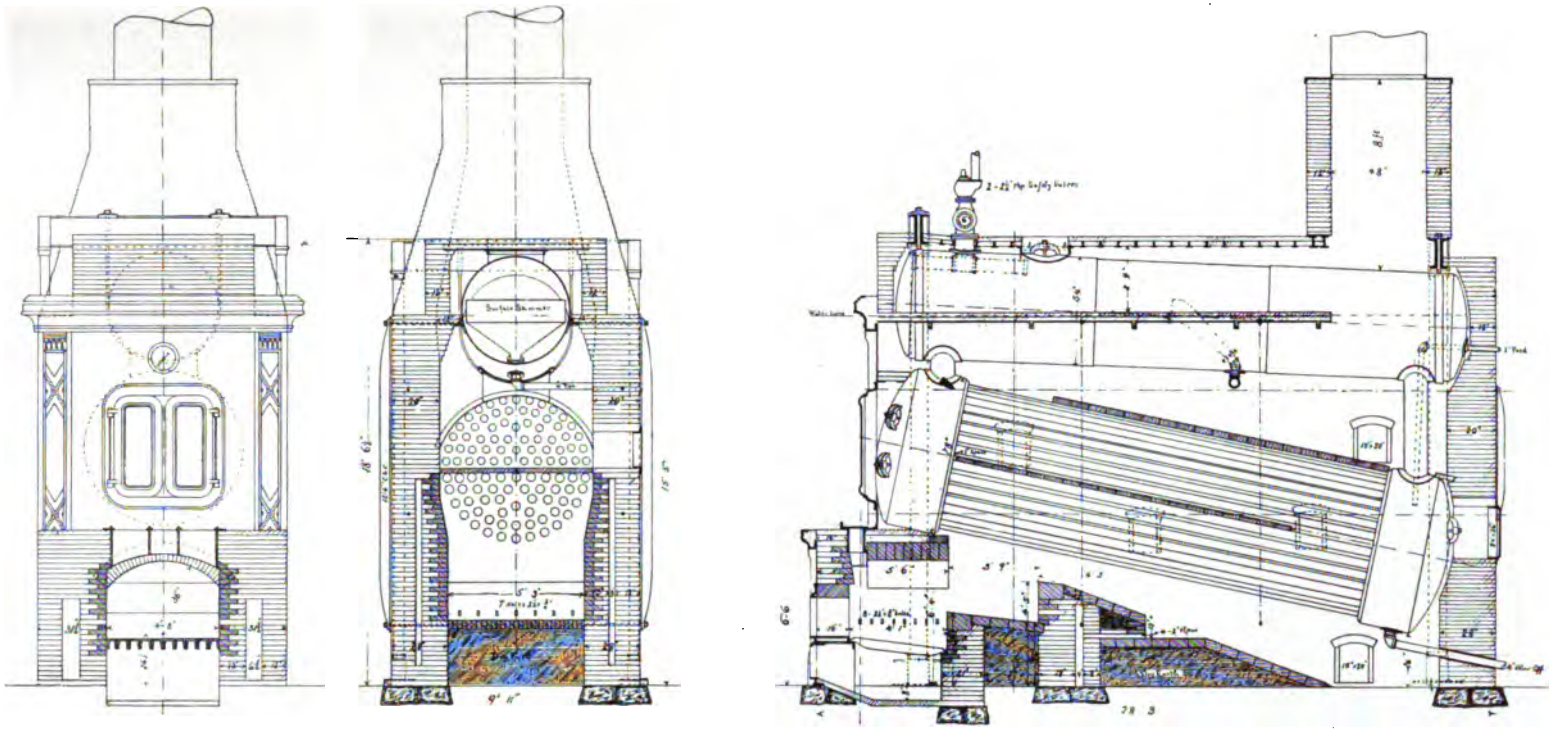

DRAWING.

Showing 200 H. P. Wood Water Tube Boiler set with Furnace for burning Dry Shavings and Sawdust, as set for The Cummer Co., Norfolk, Va.

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ECONOMY.

In considering the economy of a steam boiler, while low fuel consumption is one of the most essential points to be considered, several other things enter this economy account, which to the owner becomes of nearly equal importance.

Economy of Fuel refers to the evaporation of the greatest amount of water using the least amount of fuel. In striving to outdo their competitors, several manufacturers have claimed for their boilers the evaporation of 15 and 16 lbs. of water to one lb. of coal, and in making such a statement they have proven themselves either knaves or fools, as a little thought will readily show. Suppose, for example, that we take Youghiogheny coal, which is one of the best bitum-

ROYSTON STRAW WORKS COMPANY, GRAND RAPIDS.
OPERATED BY ONE 125 H. P. WOOD WATER TUBE BOILER.

inous coals yet developed in this country. Reference to the fuel table shows this coal contains 14,265 heat units. According to the best authorities, about 20 per cent. of these heat units are lost in heating up the chimney and by radiation through the walls; therefore, there are left but 11,412 units provided the combustion of fuel is perfect, which is rarely the case. The number of units required for evaporating one pound of water from the standard "from and at 212°" is 966, so that 11,412 divided by 966 gives 11.8 lbs. of water to one of the above coal. Anything claimed over 12 lbs. therefore, is an

Economy in Fuel.

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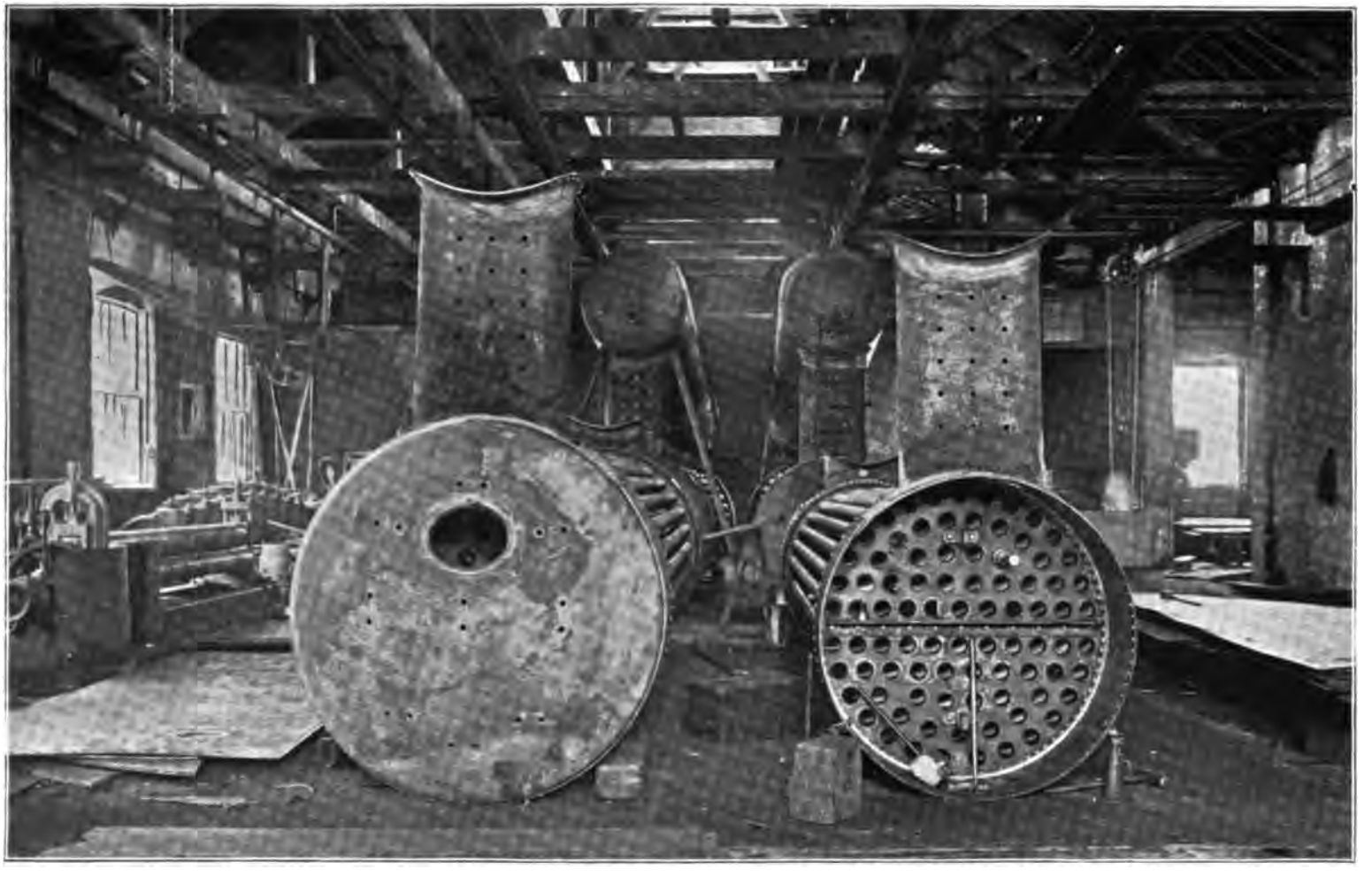

BOILER SHOP INTERIOR, LOOKING WEST, IN WATER TUBE DEPARTMENT.

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absurdity, as in ordinary boilers and their usual practice, not over seven or eight lbs. of water to one of coal is obtained.

As is explained elsewhere, the number of passages of heat given through the **Wood Boiler,** and the method of holding this heat to the water heating surface of the boiler, ensures an absorption of heat nearly reaching the ideal, as our many tests shown elsewhere in this work go to testify.

Economy of Space is, either in locations where land is very valuable or for local reasons, an important factor and deserving of more than casual attention. The **Wood Boiler** gives a maximum of power in a minimum of space consistent with good construction. Annoying shut-downs or delays caused by some part giving out, which requires sending miles away and waiting for, often means a large loss to manufacturers, where the absence of such liability is a source of economy of great magnitude. None of these considerations should be lost sight of although their relative importance may be different under different circumstances.

RESULT OF TUBULAR BOILER EXPLOSION.

SAFETY.

The reports of the various Boiler Insurance Companies are flooded with accounts of terrific destruction of life and property, as a direct result of boiler explosions. These catastrophes are among the most terrible accidents that have marked the advance of civilization. Beginning early in the 18th century, these explosions have increased in frequency and destructiveness as each manufacturer has striven to outdo his competitor in cost of production, by taking advantage of the economy in higher steam pressures, until the fluid in the boilers has a total energy, pound for pound, only comparable with that of gunpowder. This subject has attracted the attention of engineers and men of science, and it several years ago became evident that something for a boiler must be designed that would, as far

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A DISASTROUS HORIZONTAL TUBULAR BOILER EXPLOSION.

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as possible, be safe under all ordinary conditions of use and for high pressures. The only boiler yet introduced which meets with these requirements is the boiler commonly known as the Water Tube, and the patent office records are full of boiler designs on these lines, a few of which are well known and thoroughly reliable. To meet the present demand, the parts exposed to steam pressure must be of such form, quality of material, and dimensions, as to give a factor of safety so large as to remove all likelihood of their failure, even if temporarily subjected to pressure materially in excess of that ordinarily employed.

Requirements of Safety.

Prof. Thurston says: "In the United States, according to his best estimates, one boiler in ten thousand explode among those which are regularly inspected, and ten times that number among uninspected and uninsured boilers. Boilers used in saw mills are most frequently exploded, presumably because of cheapness of their construction and unskillfulness exhibited in their management; boilers in mines are next in number of casualties."

The **Wood Boiler** is designed throughout with this important factor clearly in mind, and our construction employs the use of a factor of safety of such a magnitude as to place explosion beyond the limit of possibility.

DURABILITY.

Scarcely less in importance than the fuel economy of a boiler is the question of durability. This is not always, or generally, a matter of the lifetime of the boiler; what is usually of greater importance is the liability of the parts to fail, rendering frequent stoppage for repairs and renewal necessary; while such repairs are costly in themselves, the loss from stopping is ordinarily much greater in amount. The boiler should be so constructed that, while necessity of repairs or renewal of parts is not probable, all parts of it can be got at, owing to simplicity of construction and accessibility should repairs or renewals be required. The **Wood Boiler** being made entirely of steel, and constructed with its positive and free circulation, its perfect allowance for easy expansion and contraction, has made it a most durable boiler. Should, for any cause, repairs become necessary, they can be made at once and by any boiler maker, who can furnish the material and labor at once, thereby reducing delays to a minimum. Repairs, however, on the **Wood Boiler** are not at all likely to occur, as there is no cast iron used in our entire construction, which is the dangerous element.

How Durable.

ACCESSIBILITY AND METHOD OF CLEANING, SHOWING WHAT TWO MEN CAN DO.

Owing to cylindrical construction of the **Wood Boiler,** having four manholes in front head and one in rear, when boiler is opened up for examination or cleaning, it is only necessary to open up one manhole plate in each head, the cylinders being large enough to admit a man for cleaning and repairing and give access to every tube, while in other types of water tube boilers it would be necessary to

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open up from one hundred to two hundred and fifty hand plates, caps or plugs, which would necessitate a much greater expense. This construction makes the **Wood Boiler** the simplest, most economical and accessible water tube boiler on the market.

The more accessible you make a boiler the easier it is to clean, and consequently the better it will be cleaned. The cleaning of boilers is in the majority of cases done on Sunday, and no man likes to spend all day Sunday and part of Sunday night in cleaning out a boiler, and no man will do this and do his work properly.

In the **Wood Boiler,** when the fireman, with his helper, walks in Sunday morning they open the blow-off cock to allow the boiler to empty, and while emptying they erect a suitable platform and get together the necessary tools and appliances for opening up the boiler and cleaning it out. The water being out, they open

No. 1. DOORS OPEN, REMOVING MANHEAD.

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the flue-cap doors and apply a wrench to the manhead nuts, removing nuts, crabs and manheads from one or two of the manholes in the front tube cylinder, as well as the one manhead in the rear tube cylinder. The fireman then enters the boiler, and is able to at once make a thorough examination of all the tubes in the boiler in five minutes from the time in which he placed his hand upon the handle of the flue-cap door. The helper in the meantime makes ready the hose, and the

No. 2. MAN GOING INTO BOILER.

boiler is given a thorough washing; after this operation is completed a second examination is made, to detect the formation of any scale. If there are no signs of scale present in the boiler, as is frequently the case, the boiler is closed up and filled with water, the task having been completed in a most thorough and workmanlike manner in two hours duration. If the boiler has been in long service and there are signs of incrustation forming, the tubes are then thoroughly scraped out and given a second washing, when the

Two Hours Work.

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boiler is closed up, filled with water, and the men are away in five hours, ready for an afternoon's enjoyment, with a clear conscience for having done their work properly.

Boilers which have a hand hole plate or cap over each tube cannot even be opened up for inspection in the last named time, to say nothing of the time required to close them. The four manholes are placed in the front head to permit the easy and quick removal of a tube, should it be necessary. This task can be accomplished with the same ease and dispatch by an ordinary mechanic as characterizes our cleaning.

No. 3. CLEANING COMPLETED, CLOSING UP DOORS.

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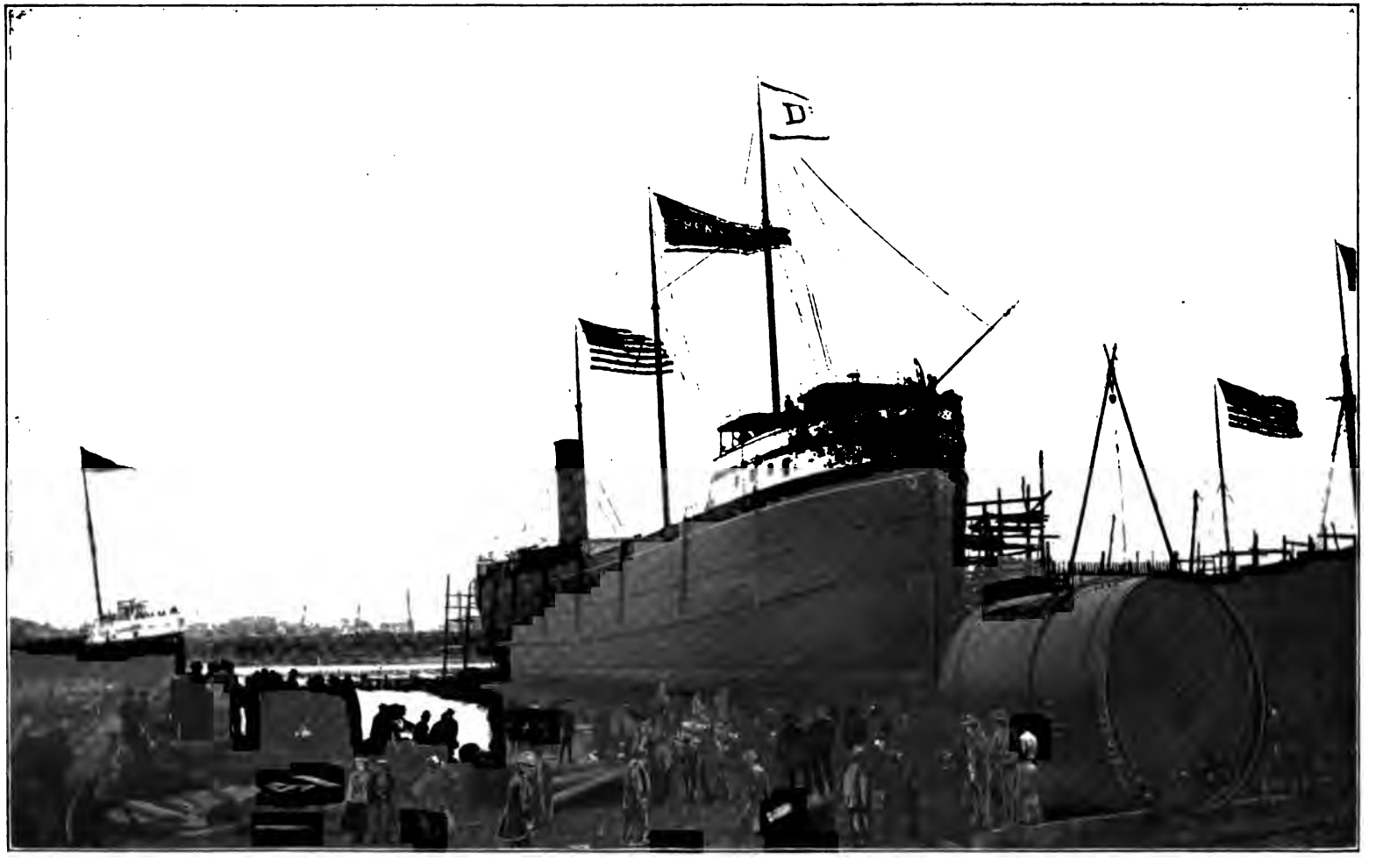

STEAMSHIP "SHENANDOAH."

BUILT BY JAMES DAVIDSON, BAY CITY, MICH. THE LARGEST WOODEN STEAMER ON THE GREAT LAKES. BOILERS, TWO 13 FT. X 13 FT. SCOTCH MARINE.

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MARINE BOILERS.

THE two types of marine boilers which we have manufactured very largely and which are in use almost universally in the freight and passenger vessels on the Great Lakes, are the Scotch marine boiler and the Fire-box marine boiler.

The Scotch marine boiler is a cylindrical boiler with the fire boxes or furnaces, also cylindrical, placed in the lower half of the boiler. These furnaces are connected to a combustion chamber or chambers, in the rear of the boiler.

STEAMER "PLEASURE."
OWNED BY DETROIT, BELLE ISLE & WINDSOR FERRY CO. EQUIPPED WITH TWO 10 FT. X 12 FT. SCOTCH BOILERS, ALLOWED 130 LBS. PRESSURE.

The combustion chamber is connected to the front tube sheet, where the britchen or uptake is connected, by the small return tubes. This allows the fire to pass back through the furnaces, up through the combustion chambers, and out through the small return tubes to the britchen and stack.

These boilers vary in size from seven to fifteen feet diameter. The small boilers contain one and two furnaces, and the large boilers three and four. These furnaces sometimes run into one common combustion chamber connecting all the furnaces, but the type used in later years is a single combustion chamber to each furnace, so that they are entirely independent.

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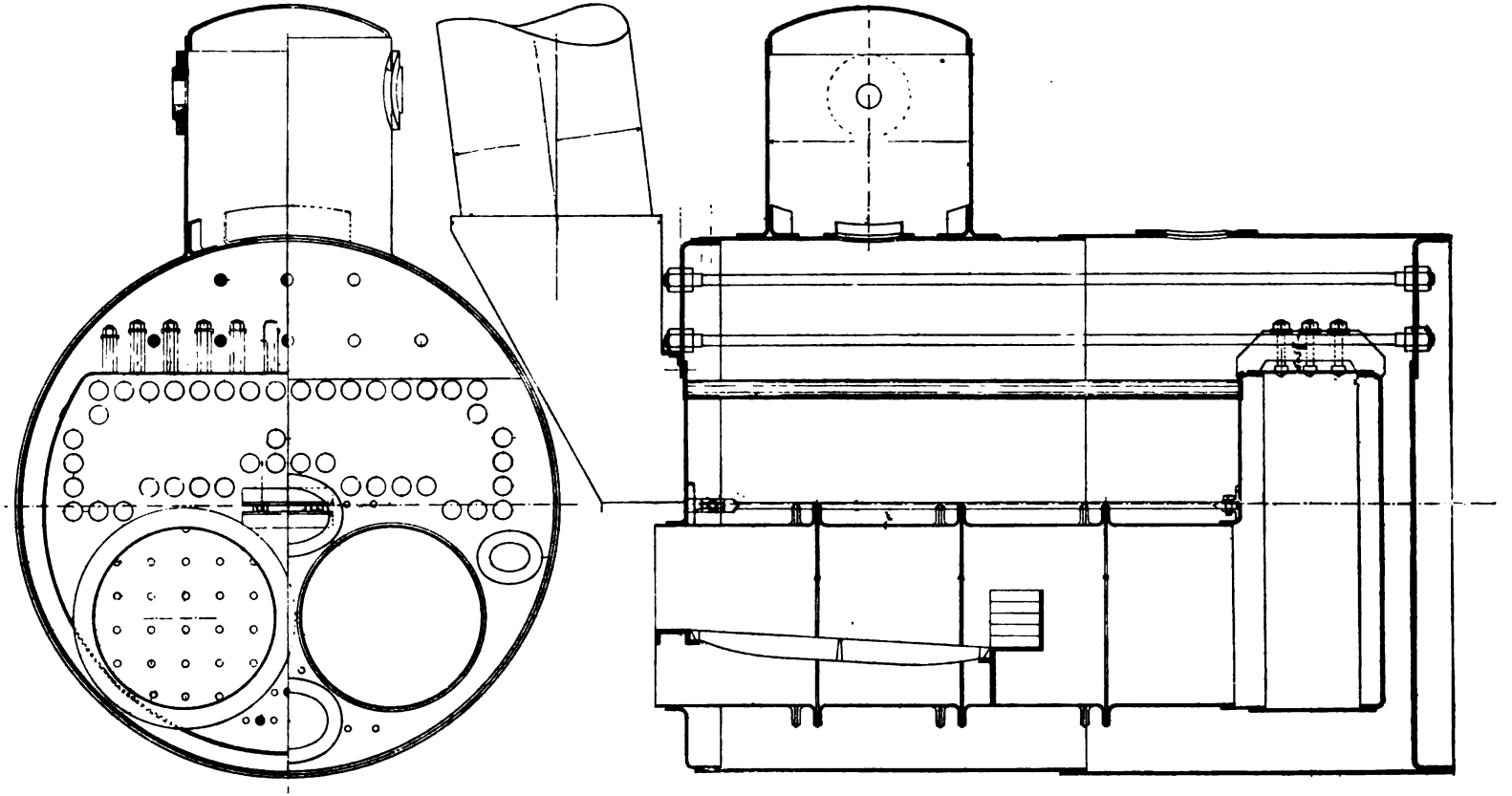

DRAWING.

Scotch Marine Boiler with Two Furnaces, "Plug Hat" Dome.

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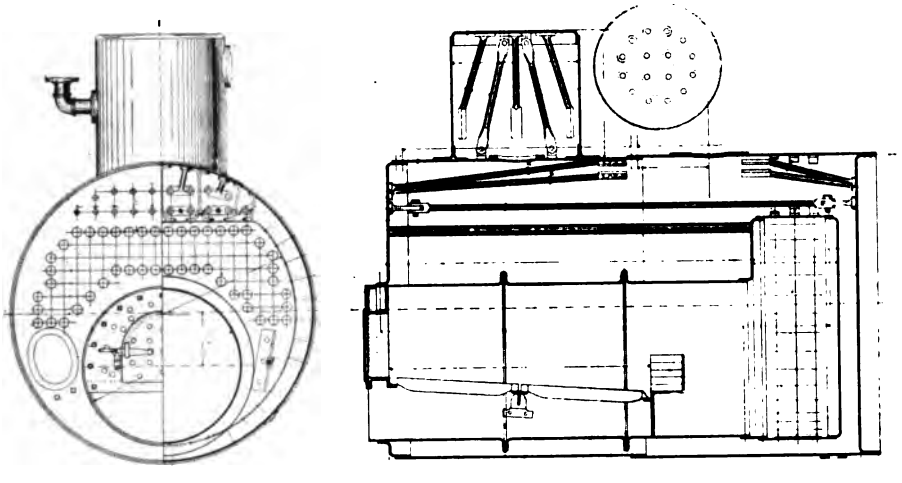
This form of marine boiler combines a large amount of heating surface in a small space, and is also very accessible and easy to clean.

The fire-box marine boilers range in size from four to twelve feet diameter of shell.

The number of fire-boxes in these boilers depends upon the size of the boiler. These fire-boxes are rectangular, and are connected to the combustion chambers by a series of large tubes, ranging in diameter from six to thirty inches. The combustion chambers are connected to the front tube sheet, where the britchen is attached, by the small return tubes.

This type of boiler combines a large amount of heating surface in a small space, but the rectangular shape of the furnaces necessitates a large amount of bracing, consequently the boiler is not as easy to keep clean.

The material for both of these types of boilers is inspected by the United States inspectors at the plate mills which furnish us material, and is all inspected



DRAWING.

Scotch Marine Boiler with Single Furnace. "Plug Hat" Dome

in conformity with the United States marine inspection laws governing this class of material. The thickness of material, size and spacing of rivets, size and spacing of braces, and the general construction of these boilers, are all laid down under the general rules and regulations published by the Board of United States Supervising Inspectors of Steam Vessels. The work, during its progress through the shop, is subject to the inspection of this board's inspectors, and after the boilers are completed and placed in the vessels they are subject to a rigid inspection before they are tested, and are all tested to a hydrostatic pressure fifty per cent greater than the steam which they are to be allowed to carry. After they have been tested they are again inspected by the Government Inspectors, to see that the bracing and all the material have stood the strain as they were originally intended.

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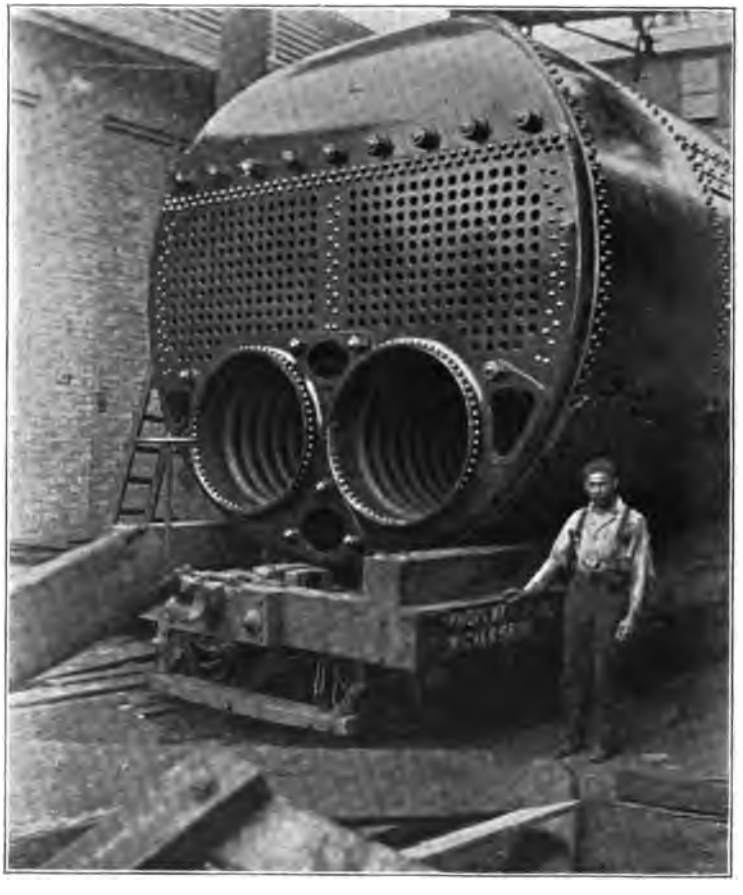
If the boilers are built and constructed in accordance with the rules and regulations, and stand the test and inspection, they are allowed to carry the pressure which these rules and regulations lay down. This inspection not only takes place when the boilers are built, but also every year of their life, and as the boiler deteriorates from use, the pressure which it is allowed to carry is cut down in proportion.

We have constructed a large number of the marine boilers which in late years have been placed in the largest and fastest freight and passenger vessels on the lakes, among which are the steamers "Centurion," "S. S. Curry," "Merida," and "Shenandoah."

A partial list of the vessels which we have equipped with our boilers will be found elsewhere in the catalogue.



FRONT VIEW OF DOUBLE ENDED SCOTCH MARINE BOILER, 12 FT. X 16 FT.
BUILT FOR U. S. REVENUE CUTTER "WM. WINDOM."

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FUEL.

IT has become acknowledged by engineers that the only method of ascertaining the relative value of fuels fairly is by comparing their calorific power or total heat of combustion. The calorific value of a fuel is expressed in British Thermal Units or Calories, according as Fahrenheit or Centigrade thermometric scales are used. The British Thermal Unit is the amount of heat necessary to raise one pound of water, at the temperature of 39.1° Fahrenheit, its greatest density, one degree in temperature. The calorific value may be determined directly by experiment or it may be computed from an ultimate chemical analysis of the coal.

Heat Unit Definition.

In order to show the varying value of the principal fuels, we add the following table, showing the average composition of fuels and the weight of air required to produce perfect combustion:

AVERAGE COMPOSITION OF FUELS.

(From Experimental Engineering).

FUEL.	Carbon. C.	Hydrogen. H.	Oxygen. O.	Ash.	Pounds of Air required for one of Fuel.
Charcoal from Wood	0.93	.....	.....	.....	11.16
" " Peat	0.80	.....	.....	.....	9.6
Coke, good	0.94	.....	.....	.....	11.3
Coal Anthracite	0.915	0.035	0.026	0.03 to 0.05	12.13
Coal, dry Bituminous	0.87	0.05	0.04	0.04 to 0.22	12.06
Coal, coking	0.85	0.05	0.06	0.04 to 0.22	11.73
" "	0.75	0.05	0.05	0.04 to 0.22	10.58
" Cannel	0.84	0.06	0.08	0.04 to 0.22	11.88
" dry, long flaming	0.77	0.05	0.15	.....	10.32
" lignite	0.70	0.05	0.20	.....	9.30
Peat, dry	0.58	0.06	0.31	5. to 15.	7.68
Wood, dry	0.51	0.057	42.0	0.01	6.00
" air dried 20 per cent. H_2O	39.6	4.8	34.8	0.01	6.00
Mineral Oil	0.85	0.15	.....	.....	15.7

STEAMSHIP "MACKINAW" OF SAN FRANCISCO.
SUPPLIED WITH TWO SCOTCH BOILERS 13 FT. 4 IN. X 13 FT., ALLOWED 165 LBS. PRESSURE.

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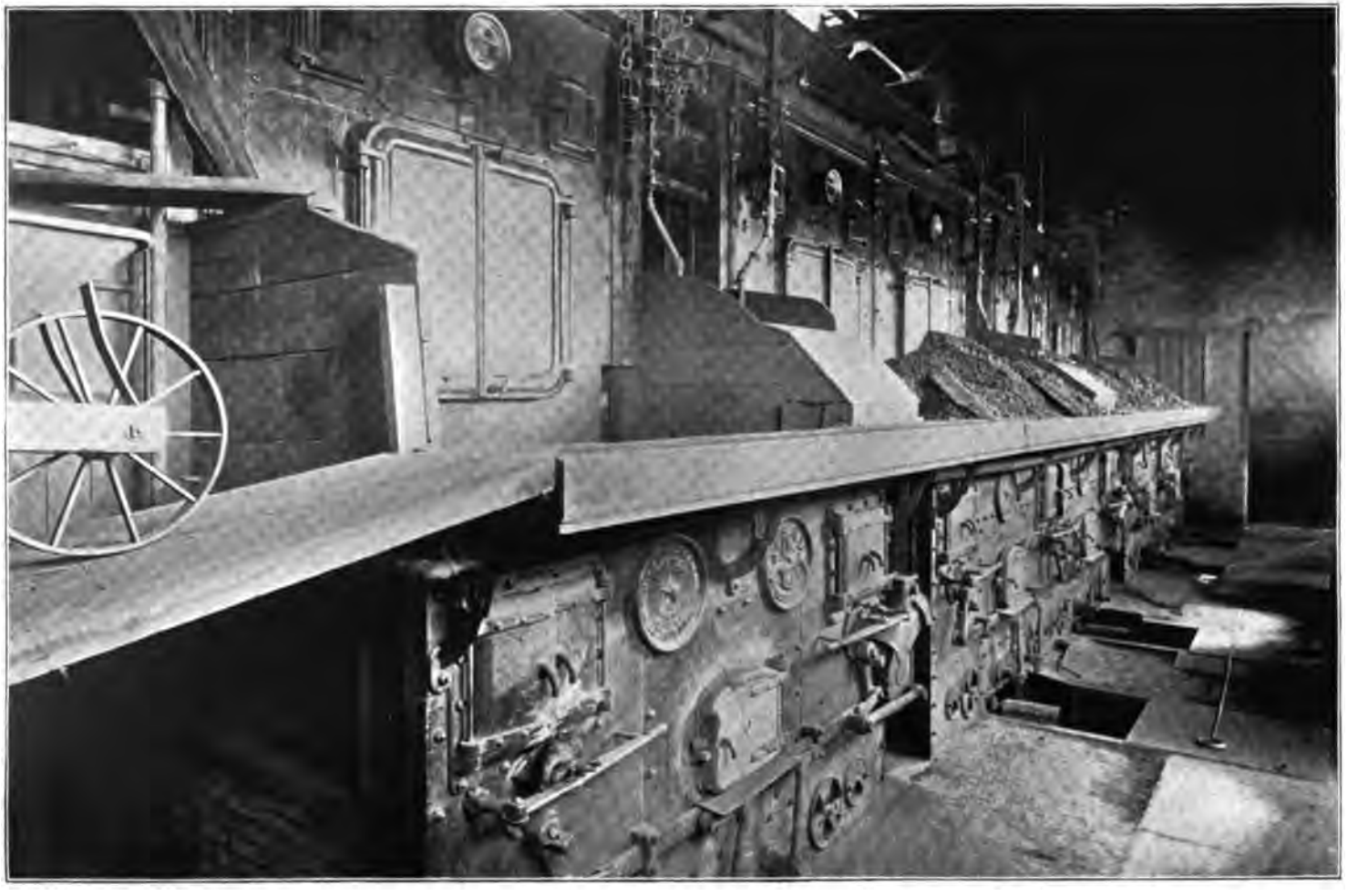

INTERIOR CALUMET ELECTRIC STREET RAILWAY COMPANY'S BOILER PLANT AT CHICAGO,
SHOWING 1,000 H. P. WOOD WATER TUBE BOILERS, EQUIPPED WITH MURPHY STOKERS.

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The following table from R. C. Carpenter, (Experimental Engineering), gives the calorific power of the principal combustible substances, and is of interest in showing the relative value of the various elementary components of fuels:

TOTAL HEAT OF COMBUSTION WTH OXYGEN.

SUBSTANCE.	Pounds of Oxygen required per pound of Combustible.	Pounds of Air required per pound of Combust'l (nearly.)	Total Heat, B. T. U. per pound.	Pounds of Water evaporated per pound of Combustible from 212.°	PRODUCT OF COMBUSTION.
Hydrogen Gas	8.	36.	62,032	62.6	H_2O.
Carbon burned to CO	1.33	6.	4,400	4.50	CO.
Carbon burned to CO_2	2.67	12.	14,450	14.67	CO_2.
Olefiant Gas	3.43	15.43	21,344	22.1	CO_2 and H_2O.
Liquid Hydro-Carbon	.....	.....	19,000 21,700	20. 22.5	CO_2 and H_2O.
Sulphur to SO_2	1.	4.5	3,740	4.09	SO_2.
Silicon to SiO_2	2.29	10.2	14,000	14.24	SiO_2.
Phosphorus to P_2O_5	1.44	6.5	10,250	10.45	P_2O_5.
Marsh Gas, C_2H_4	3.55	16.2	26,400	26.68	CO_2 and H_2O.
Bisulphide of Carbon, CS_2	1.28	5.7	5,750	6.18	CO_2 and SO_2.
Carbonic Oxide	1.33	6.	10,100	10.4	CO_2.
Crude Petroleum	2.8	15.0	18,600	18.53	CO_2 and H_2O.

COAL.

This fuel being most widely known and used throughout the United States deserves first place in our consideration, but the calorific power and proportions of its chemical elements, vary to such a degree not only in different locations but even in the different veins in the same mine, that it is impossible to quote any standard.

The report of the U. S. Government on the Geological survey divide, for convenience of description, the coal area of the United States into the Anthracite division and the Bituminous division.

The Anthracite division, in a commercial sense, may be said to include the anthracite districts of Pennsylvania alone, although small amounts of anthracite are mined in Colorado, Arkansas and New Mexico.

The Bituminous division includes the following coal fields: (1) The Triassic field, embracing the coal beds of the Triassic or New Red Sandstone formation in the Richmond basin in Virginia, and in the coal basins along the Deep and Dan rivers in North Carolina; (2) the Appalachian field, which extends from the State of New York on the north to the state of Alabama on the south, having a length northeast and southwest of over 900 miles, and a width ranging from 30 to 180 miles; (3) the Northern field, which is confined exclusively to the central part of Michigan; (4) the Central field, embracing the coal areas in Indiana, Illinois and western Kentucky; (5) the Western field, including the coal areas west of the Mississippi river, south of the forty-third parallel of north latitude

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and east of the Rocky Mountains; (6) the Rocky Mountain field, containing the coal areas in the States and Territories lying along the Rocky Mountains; (7) the Pacific Coast field, embracing the coal districts of Washington, Oregon, and California.

These different fuels vary in the proportion of their chemical constituents as widely as the area over which they are spread.

U. S. REVENUE CUTTER WM. WINDOM'S DOUBLE ENDED SCOTCH BOILER, WEIGHING 65 TONS. LOADED ON A SPECIALLY CONSTRUCTED CAR.

The following table, which we have compiled from the practical tests and deductions of various writers, gives the comparative value of some American coals:

HEATING VALUE OF FUELS.

(Stated in British Thermal Units.)

PENNSYLVANIA—	
Anthracite Coal	14,199
Semi-Bituminous Coal	13,155
Youghiogheny Coal	14,265
" Slack	11,664
Turtle Creek	14,150
Leiseuring	15,005
KENTUCKY—	
Cannel	15,198
Lignite	9,326
ILLINOIS—	
Big Bureau County Coal	13,110
Streator	11,265
Big Muddy	11,576
Gillespie	10,506
MARYLAND—	
Georges Creek	14,217
Eureka	13,427
INDIANA—	
Block	13,588
Cannel	13,097
OHIO—	
Massillon	12,680
Hocking Valley	13,411
WEST VIRGINIA—	
Pocahontas	13,608
New River	14,455
American Petroleum	20,385
Charcoal Wood	10,800
Peat Dessicated	9,951
Tanbark Moist	4,284

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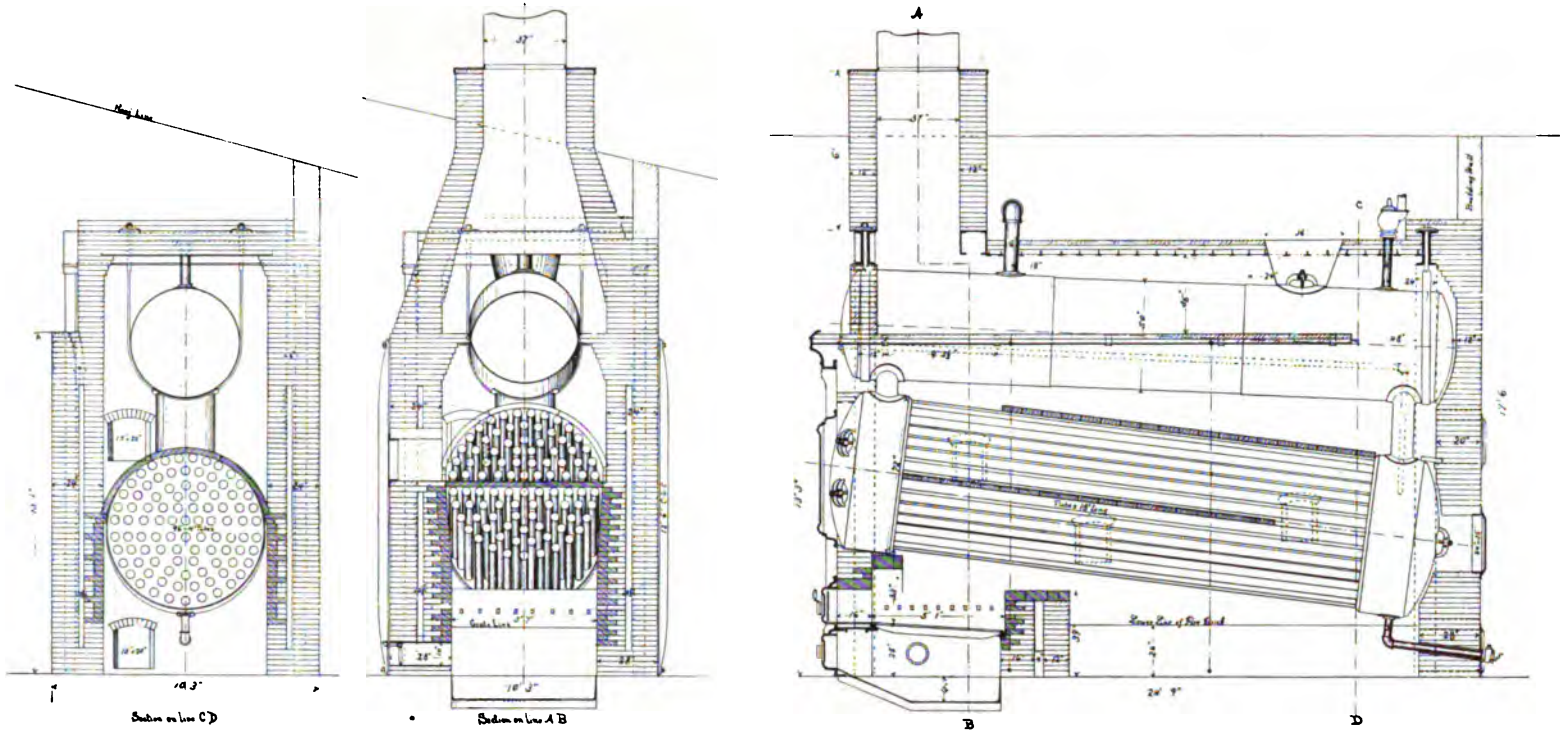

DRAWING.

Showing a 175 H. P. Wood Water Tube Boiler with Four Passages for Products of Combustion, as set for Saginaw Milling Company.

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Since what is known among chemists as "a proximate analysis" of coal is now being put forward by the various coal dealers quite commonly, in connection with their solicitation for trade, we give the following table which has been compiled by Mr. Wm. Kent after making a most thorough investigation of the results obtained by Mons. P. Mahler in his elaborate research. The table is based on the assumption that the calorific power of a coal is proportional to its percentage of fixed carbon:

TABLE FOR DETERMINING THE APPROXIMATE HEATING VALUE OF COALS.

Percentage of fixed Carbon in Coal dry and free from Ash.	Heating Value.		Percentage of fixed Carbon in Coal dry and free from Ash.	Heating Value.	
	Calories.	British Thermal Units.		Calories.	British Thermal Units.
97	8,200	14,760	63	8,400	15,120
94	8,400	15,120	60	8,100	14,580
90	8,600	15,480	57	7,800	14,040
87	8,700	15,660	54	7,400	13,320
80	8,800	15,840	51	7,000	12,600
72	8,700	15,660	50	6,800	12,240
68	8,600	15,480			

OIL.

The use of oil, as fuel, has become a live question, and has attracted the attention of many engineers and managers of steam plants. Actual trial of oil, keeping accurate records of cost of oil, loss of steam to atomize the oil, labor saving over coal, and other results, will be the only absolute answer to the question, "Does it pay?"

As the oil equipment is somewhat costly, and the cost and quality of oil varies so much in different localities, it is best to gather as much reliable data outside as possible before making the attempt.

David S. Day, in his work "Mineral Resources of the United States, 1893," divides the oil producing fields into four districts, the Appalachian, Lima, Florence of Colorado, and Southern Californian.

Weight of Gallon.

The Appalachian and the Lima oils are the oils most widely known in this region. These vary in their quality to a marked degree, causing the weight per gallon to fluctuate between six and seven pounds. The average price of certificate oil in the Appalachian fields in 1893 was sixty-four cents per barrel of forty-two gallons. In the Lima field in 1893, the average price of oil was forty-seven and one-fourth cents per barrel of forty-two gallons. To these prices must be added the carrying charges, which cause a fluctuation in price according to localities.

Gallons per Barrel.

One of the most exhaustive tests and comparisons between oil and coal was made at the power plant of the Twin City Rapid Transit Co., Minneapolis and St. Paul, Minn., by Messrs. Wm. A. Pike and T. W. Hugo, the results of which

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KORTLANDER & MURPHY BUILDING, GRAND RAPIDS, MICH.
SUPPLIED WITH WOOD WATER TUBE BOILERS.

were later presented before the American Society Mechanical Engineers, as follows: On the comparative value of coal and oil, oil costing $0.0226 per gallon, and coal that would evaporate from and at 212° Fahrenheit, 7½ pounds of water to one of coal, we learn that when such

Does it Pay?

Coal costs $2.00 per ton, saving over oil was 37.1 per cent.
Coal costs $2.25 per ton, saving over oil was 31.9 per cent.
Coal costs $2.50 per ton, saving over oil was 26.9 per cent.
Coal costs $3.00 per ton, saving over oil was 16.7 per cent.
Coal costs $3.85 per ton, EQUAL.
Coal costs $4.85 per ton, cost above oil was 19.5 per cent.

These results include the difference in cost of handling coal, ashes and oil.

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The oil used gave the following as the results of five chemical analyses:

Hydrogen .....13.03 per cent.
Carbon .....82.38 per cent.

Theoretical Evaporation, 20.63 pounds water from and at 212° Fahrenheit, per lb. of oil.

The Pennsylvania oil is usually credited with a theoretical evaporation of between 21 and 23 lbs. of water from and at 212° Fahrenheit, per lb. of oil.

There are, perhaps, a few localities where oil can be used with economy, and there are also some plants having such delicate machinery that the absence of the dust and grit accompanying the use of coal is most desirable, but ordinarily speaking, at present prices, oil is an expensive fuel.

STEEL STEAMSHIP "W. H. GILBERT" OF THE NEW YORK CENTRAL & HUDSON RIVER R. R. LINE.
BOILERS, THREE 12 FT. X 12 FT. SCOTCH MARINE. PRESSURE 165 LBS.

WOOD.

The use of wood as fuel for steam generating purposes has long since passed out of use, save, possibly, in a few remote localities and in a special form in those manufacturing plants where wood working machinery is extensively used.

The calorific value of dry wood is 7245 B. T. U. or a theoretical evaporation from and at 212° of 7.5 lbs., while wood containing 20 per cent. hygrometric water has 5600 B. T. U., or 5.8 lbs. evaporated from and at 212° Fahrenheit.

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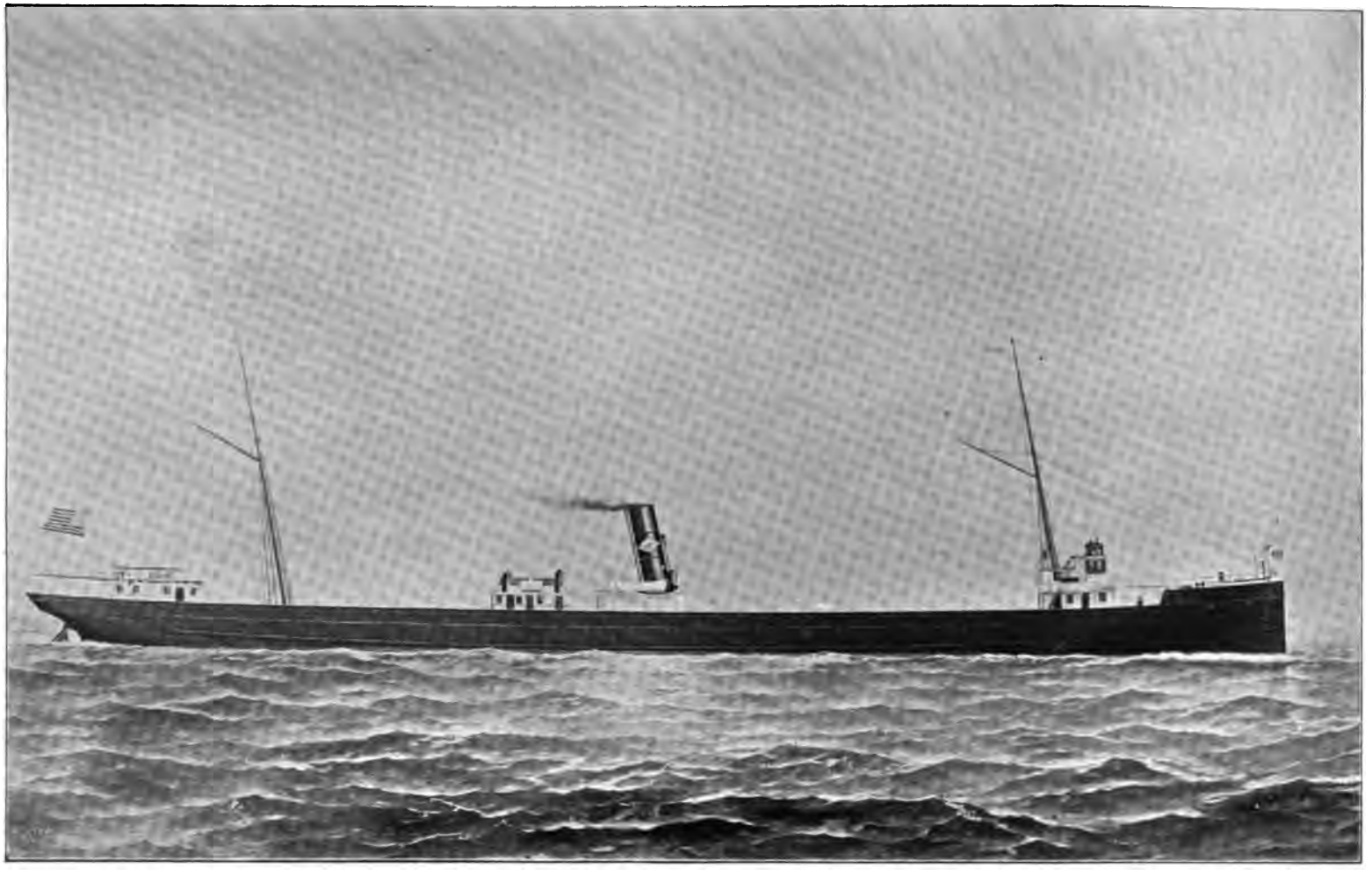

STEAMSHIP "S. S. CURRY," THE LARGEST FREIGHT CARRIER ON THE GREAT LAKES.

RECORD: ORE, 5,117 NET TONS; GRAIN, 250,000 BUSHELS OATS; COAL, 4,435 TONS; BOILERS, 3 SCOTCH MARINE, 12 1-2 FT. X 12 FT; PRESSURE, 170 POUNDS.

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It is generally conceded that 2¼ lbs. of good dry wood are equivalent in evaporative effect to one lb. of good coal, and the American Society Mechanical Engineers have adopted for use in boiler tests four-tenths lb. coal equal to one lb. of wood. The fuel value of the same weight of different wood is very nearly the same, that is, a pound of hickory is worth no more for fuel than a pound of pine, assuming both to be dry. The chemical composition of perfectly dry wood as an average, may be taken as follows:

Value of Wood.

(Taken from D. K. Clark's Combustion of Fuel.)

Carbon	50 per cent.
Hydrogen	6 per cent.
Oxygen	41 per cent.
Nitrogen	1 per cent.
Ash	2 per cent.
	100 per cent.

The composition of ordinary fire wood, including hygrometric water, is as follows:

Hygrometric Water	25. per cent.
Hydrogen	4.5 per cent.
Carbon	37.5 per cent.
Qxygen	30.75 per cent.
Nitrogen	.75 per cent.
Ash	1.5 per cent.
	100 per cent.

The weights of one cord of different woods air dried, is as follows:

1 cord Hickory or Hard Maple weighs	4500 lbs.
1 cord White Oak weighs	3850 lbs.
1 cord Beech, Red Oak, Black Oak weighs	3250 lbs.
1 cord Poplar, Chestnut, Elm weighs	2350 lbs.
1 cord average Pine weighs	2000 lbs.

GAS.

Gas for fuel has advantages of such marked character over the other fuels, that it might well be termed the perfect fuel; and were it not for the potency of that all important factor in steam generation—"dollars and cents"—its adoption would doubtless become universal.

The perfect control under which the combustion is kept, with minimum expenditure of labor, as well as the thoroughness of the combustion without the introduction of excess of air, is recognized at once as an advantage.

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The high resultant temperature of combustion, together with the ease with which the heat can be utilized and absorbed, and the absence of any odor, are some of the other marked advantages.

Mr. Wm. Robinson classifies gaseous fuels under the following heads:

1. Natural Gas.
2. Gas from Coal, Coke, Wood and Peat.
3. Oil Gas.
4. Carbureted Air.

THREE 12½ FT. X 12 FT. SCOTCH BOILERS LOWERED IN POSITION IN STEAMSHIP "MERIDA."

There have been inventors galore bringing out apparatus for the artificial production of gas, either as coal, water, or producer gas, and while doubtless their labor will ultimately achieve success, at the present writing we know of no process which commends itself as a commercial success for steam generating purposes.

Natural gas and waste gases from blast furnaces are, however, within the range of economical production, are used more extensively and therefore deserve some mention.

Mills gives the following table showing the relative calorific value of various gases.

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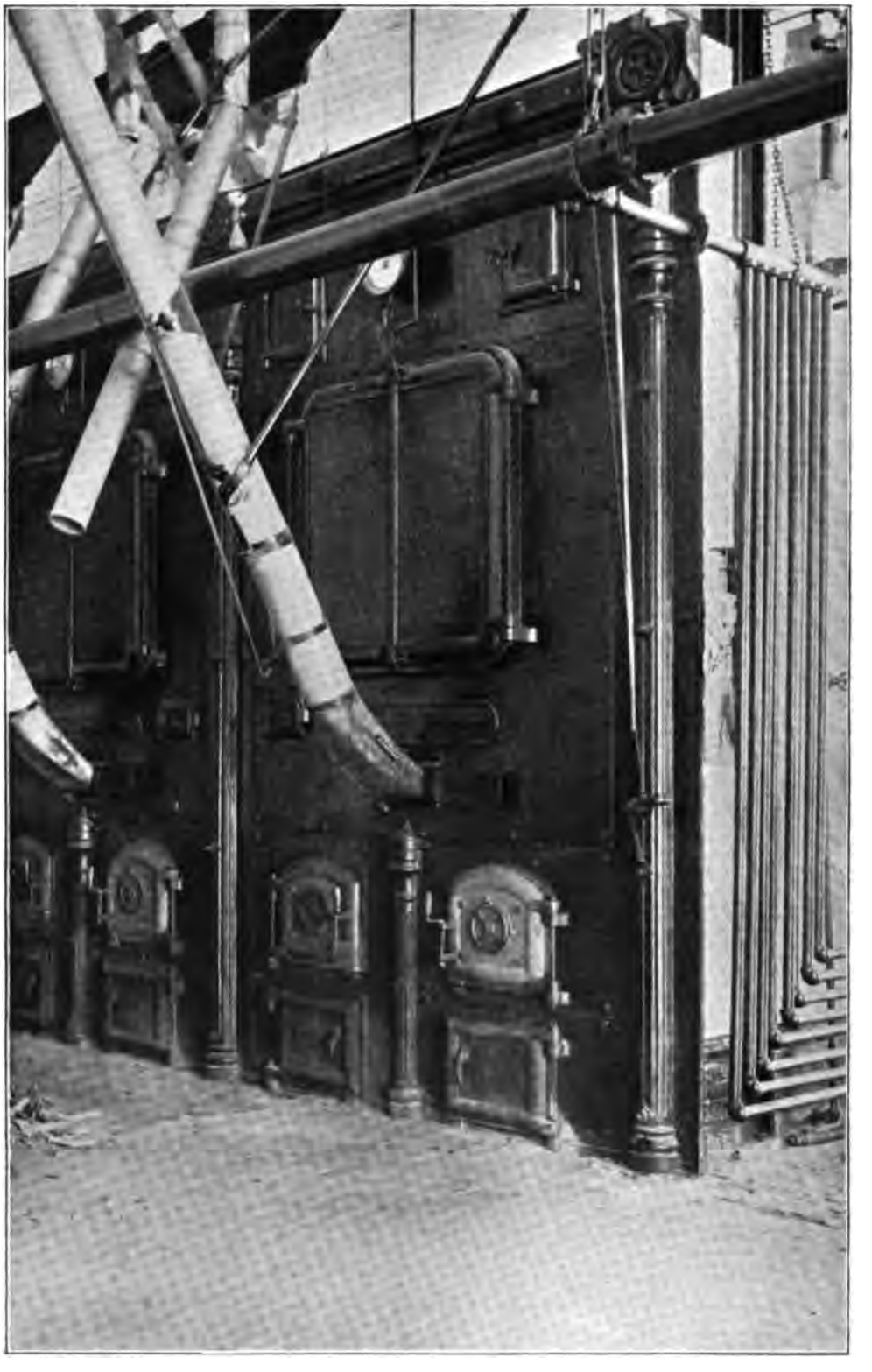

POWER PLANT GRAND RAPIDS CHAIR COMPANY, GRAND RAPIDS, MICH.
SHOWING FURNACE CONSTRUCTED FOR APPLICATION OF SHAVING AND SAWDUST FEEDERS.

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"A" denotes number of cubic feet to one pound, atmospheric pressure.
"E" denotes heat by perfect combustion of one pound of fuel in B. T. U.
"F" denotes pounds of water evaporated from and at 212°.

GAS TABLE.

	A	E	F
Marsh Gas	24.	23,513	24.34
Ill'g Gas, mixture of Hydrogen and Marsh Gas	28.7	18,725	19.38
Natural Gas	26.2	22,111	22.89
Water Gas	24.3	8,798	9.11
Gas from Blast Furnaces	.....	1,620	1.68

The most important natural gas fields are those of Pittsburgh, (Tarentum and Murraysville), Pa., Fostoria, Ohio, Findlay, Ohio and Muncie, Ind.

Natural Gas.

The composition of natural gas varies to a marked degree; not only does it vary in different wells, but in the same wells after a short lapse of time. The main constituent of natural gas, however, is marsh gas, and Thorp's Dictionary of Applied Chemistry gives the volumetric analysis as follows:

Marsh Gas	60 to 80
Hydrogen	5 to 20
Nitrogen	1 to 12
Ethane	1 to 8
Olefiant Gas	0 to 2
Carbonic Dioxide	0.3 to ·2
Carbonic Oxide	trace.

It is thus readily seen how variable is the composition, and consequently the calorific value of natural gas.

To determine the calorific value of natural gas, the American Society of Mechanical Engineers, a few years since, appointed a committee to make a determination of the relative heating values of natural gas and Pittsburgh coal. It was found that one pound of coal evaporated nine pounds of water from a temperature of from 60 to 62 degrees, and one pound of gas evaporated 20 to 31 pounds of water under similar conditions. Practically, one pound of gas is equal to two pounds of coal.

Practical Equivalent.

There are 23½ cubic feet of natural gas to one pound weight, or 42½ pounds in 1,000 cubic feet, the commercial unit.

This estimate, at the recent reduced rate of 20 cents per 1,000 cubic feet, makes the cost 4.7 mills a pound, or $10.52 a gross ton of natural gas.

As coal has one-half the calorific value of gas, its cost, at half gas rates, would be $5.26 a gross ton.

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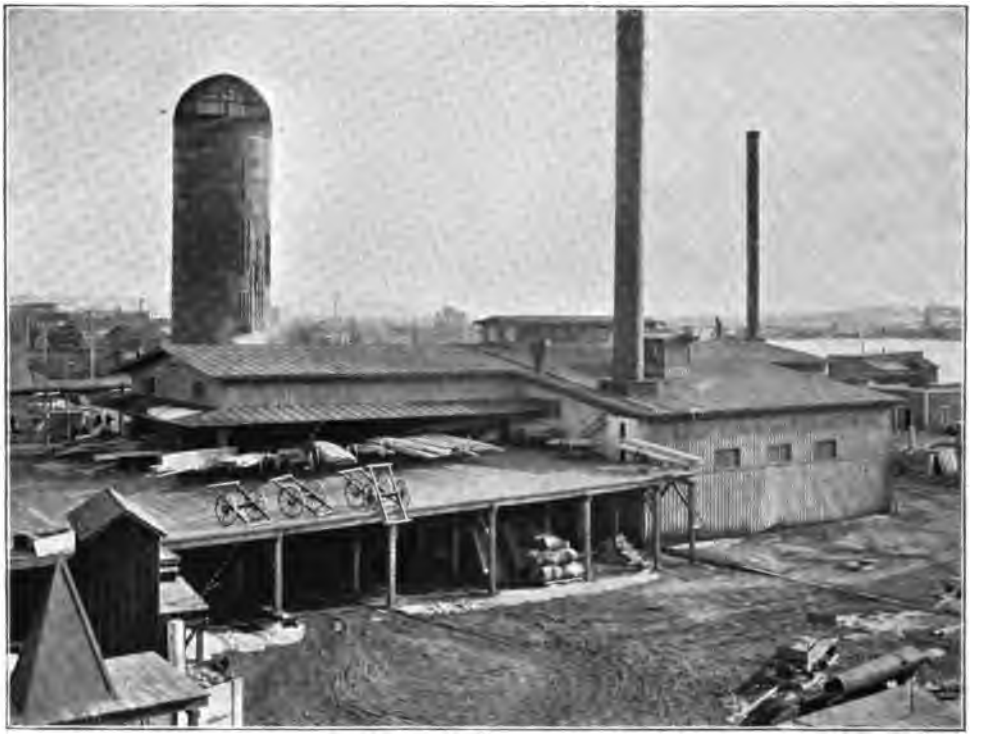
But the expenses of using coal in firing boilers, loading and disposing of ashes—48 cents a ton—would leave for the value of the coal at the boilers, $4.78 a gross ton. But the cost of coal, firing and taking care of ashes, at some large iron works will average only $1.25 a gross ton against $5.26 for its equivalent of natural gas. Equating the value of the latter to the cost of coal would reduce the price of natural gas to 9½ cents per 1,000 cubic feet. S. A. Ford, chemist of the Edgar Thompson Steel Works at

Gas Equivalent in Coal.



SAW MILL OWNED BY W. W. CUMMER, CADILLAC, MICH.
OPERATED BY TWO 200 H. P. EACH WOOD WATER TUBE BOILERS.

Pittsburgh, has made a number of analyses of natural gas, with a view of determining its heating value. He finds that 1,000 cubic feet of an average gas contains 833,766 B. T. U. and weighs 38 pounds.

Some writers claim, however, that natural gas in its calorific value, probably falls somewhere between the above figure and 1,200,000 B. T. U. per 1,000 cubic feet.

Comparing the theoretical value with Youghiogheny coal, which has 14,265 B. T U., and Ford's sample of 1,000 cubic feet at 833,766 B. T. U., we find that 1,000 cubic feet of gas is equivalent to 58.44 pounds of the coal. Owing, however, to the much higher efficiency attained by gas over coal in ordinary boiler practice, the ratio of 1,000 cubic feet equal to 75 to 100 pounds of coal, would probably form a closer parity for commercial practice.

Equivalent of Gas to Coal.

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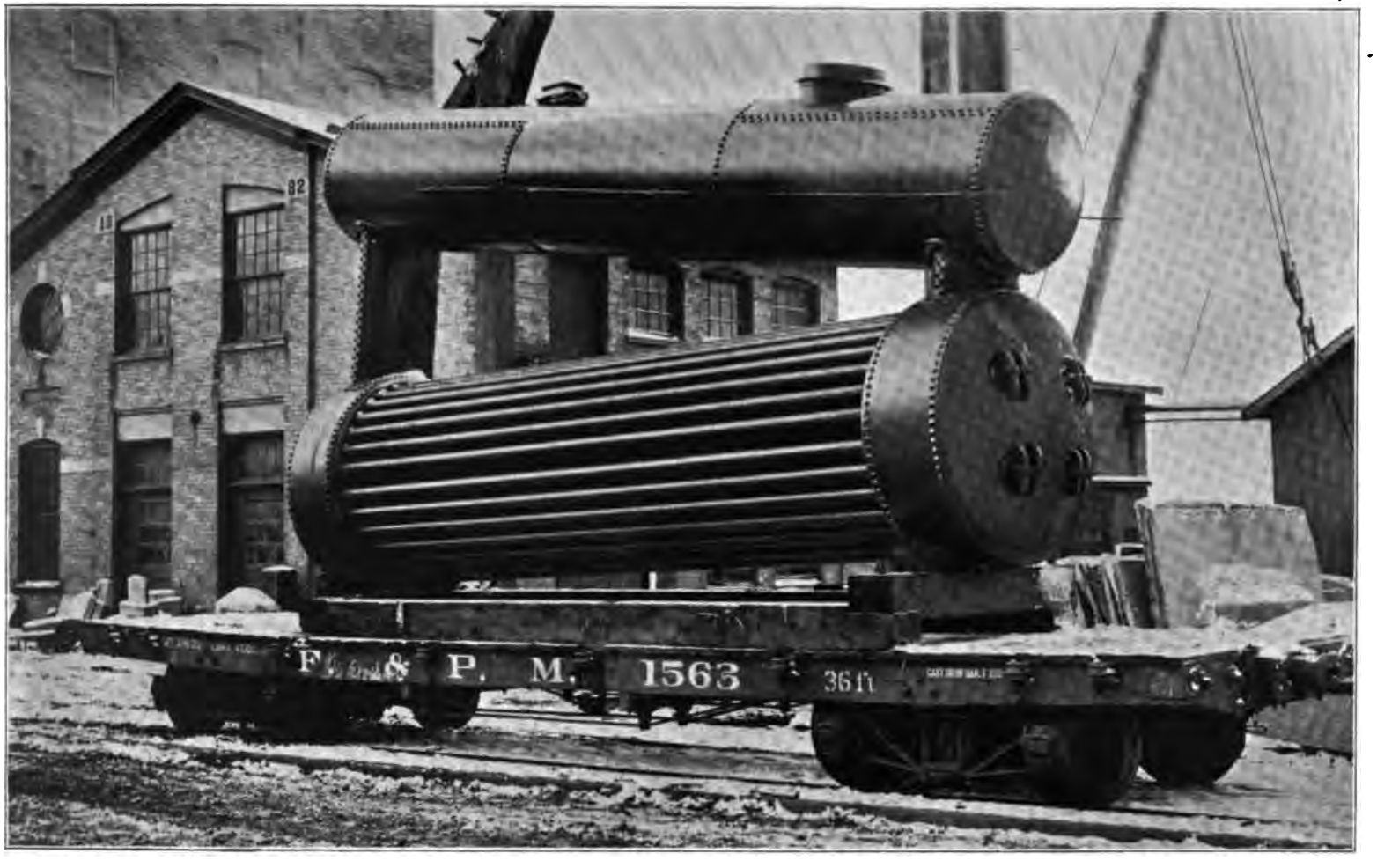

200 H. P. WOOD WATER TUBE BOILER LOADED FOR SHIPMENT.

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If a ton of the Youghiogheny coal cost $2.00, then natural gas, to be equivalent in a commercial sense, is worth from 7½ to 10 cents per 1,000 cubic feet, without taking into consideration the diminution of required labor.

BLAST FURNACE GASES.

The use of the waste products from blast furnaces is now very generally adopted, although the calorific value is low; nevertheless it is utilization of a heat otherwise driven into the atmosphere and entirely lost.

Bunsen* gives, by weight, an analysis of an average sample of blast furnace gas, as follows:

Nitrogen	59.559
Carbonic Acid	12.765
Carbonic Oxide	26.006
Light Carbureted Hydrogen	1.397
Hydrogen	.078
Condensed Hydrocarbon	.053
Sulphureted Hydrogen	.108
Ammonia	.054

The number of heat units expressed in calories in the above sample is for the 100 parts, 88,374 calories, or about 3,532 B. T. U. for one part.

Comparing this gas with Youghiogheny coal of 14,265 B. T. U., we find that one pound of coal is equal to about four pounds of the gas.

Mills gives the calorific value of a sample of waste gas as 1,620 B. T. U. which demonstrates the variable composition of these gases.

From the above, the saving is at once apparent, since an evaporation of from 1 to 4 pounds of water to one of gas, can be obtained from an otherwise lost source.

* See Crookes & Rohrig (A Practical Treatise on Metalurgy, Vol. III.)

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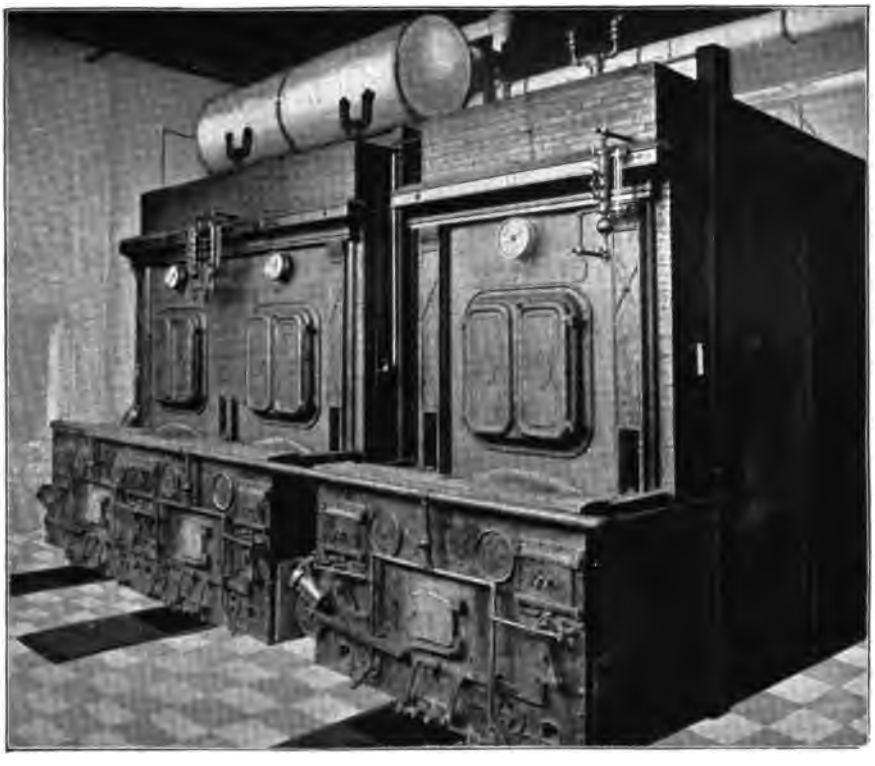

BATTERY OF THREE 200 H. P. WOOD WATER TUBE BOILERS.
THE THIRD ORDER. FOR MANUFACTURING THE CELEBRATED MORGAN & WRIGHT BICYCLE TIRE.

CHIMNEY DRAUGHT.

THE designing of a chimney of proper size, height and general construction to give the boilers the requisite draught for their best performance, is one of the first problems confronting the engineer designing a steam plant. The theoretical formulæ deduced by Pecklet, Rankine, and later by Prof. Gale and others, are of much interest to the scientist, but the engineer in designing a chimney still clings to empirical formulæ deduced from current successful practice.

What is a Chimney for?

The work of a chimney consists in promoting a flow of air through a furnace. The hot air in a chimney is lighter than the surrounding atmosphere, which therefore, endeavors to force its way into the chimney from below in order to restore the balance of pressure. The only way into the chimney is through the grate bars, fuel and furnace, and in passing through these the air maintains the combustion and at the same time becoming itself highly heated, makes the action of the chimney continuous.

The intensity of the draught varies about as the square root of the height, and the required intensity of draught depends upon the character of fuel to be

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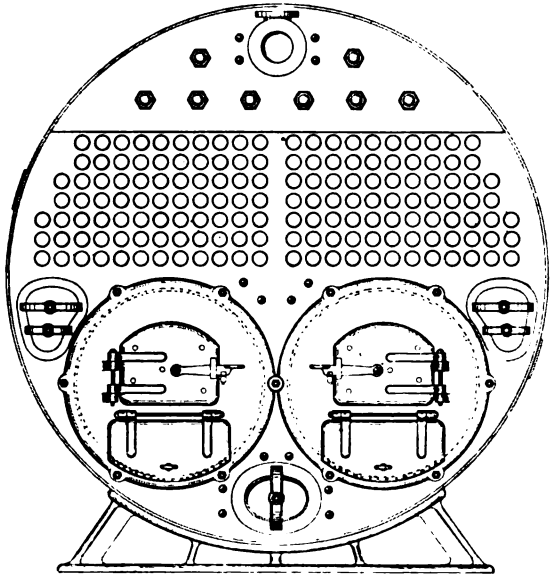

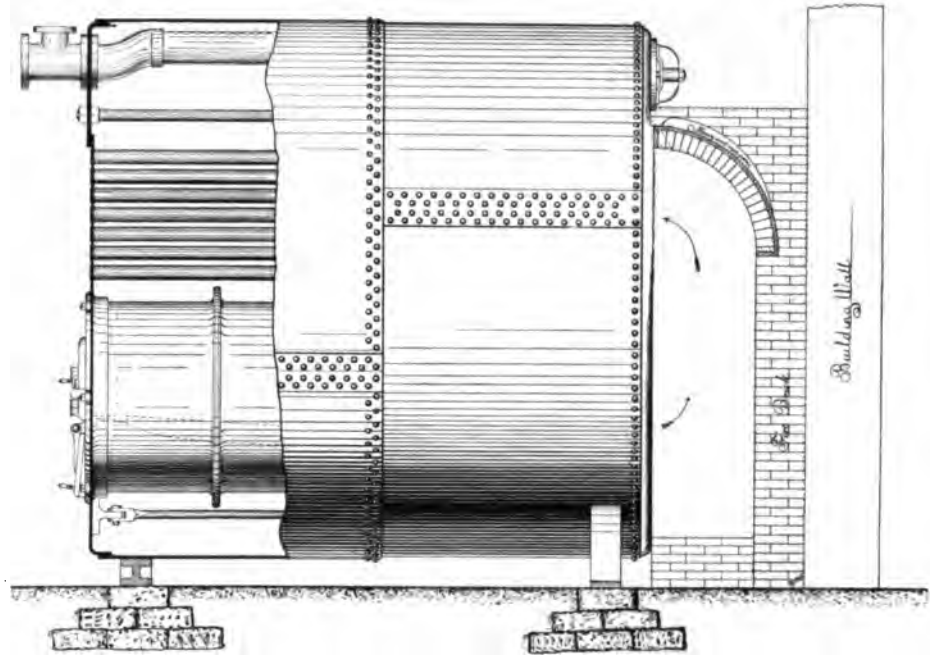

DRAWING.

Scotch Boiler with Brick Return for Stationary Purposes for High Pressure.

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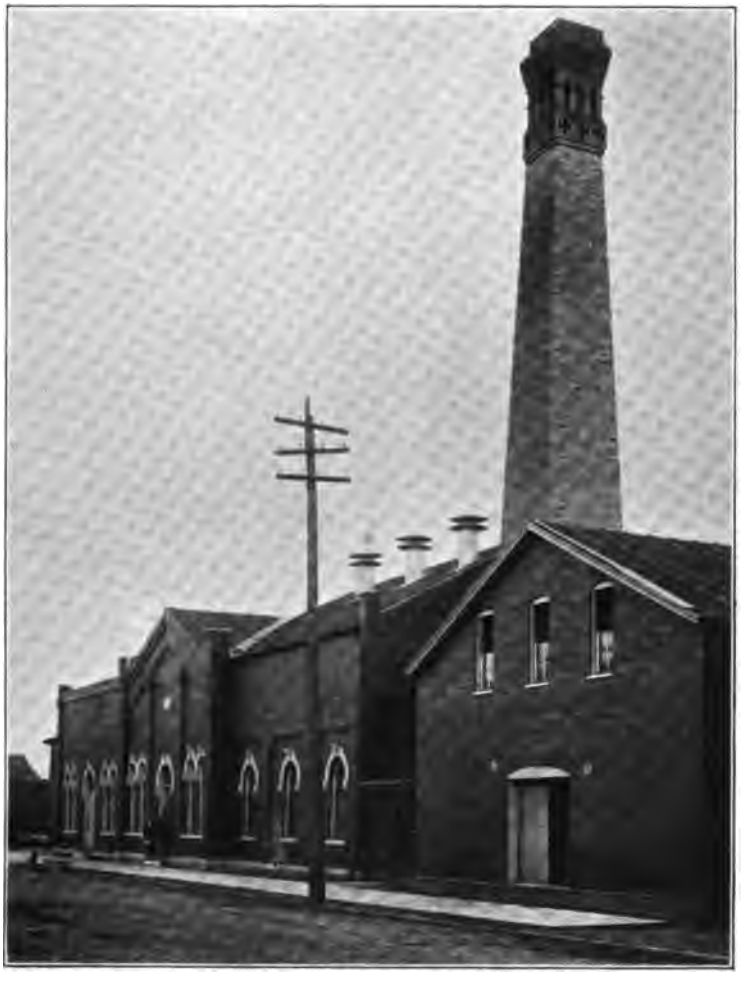
used and the rate of combustion desired, being least for wood and greatest for the fine low grades of fuel.

While the intensity is a function of the height, the height must be governed not only by the desired intensity, but by the existing conditions, care being taken to be above surrounding hills and buildings.

The effect of height in a chimney is expressed by the difference between the weight of a column of outside air of the height of the chimney above the grate bars standing on a base equal in area to the cross section of the chimney, and



WATER WORKS PLANT, SAGINAW, MICH.
EQUIPPED WITH THREE 125 H. P. WOOD WATER TUBE BOILERS

that of a column of hot air within the chimney. This difference is the measure of the force which produces the draught. A column of hot gas equal in weight to the difference is called the head of the chimney. The height of the head reckoned in feet of hot gas is found by dividing

The Head of Chimney.

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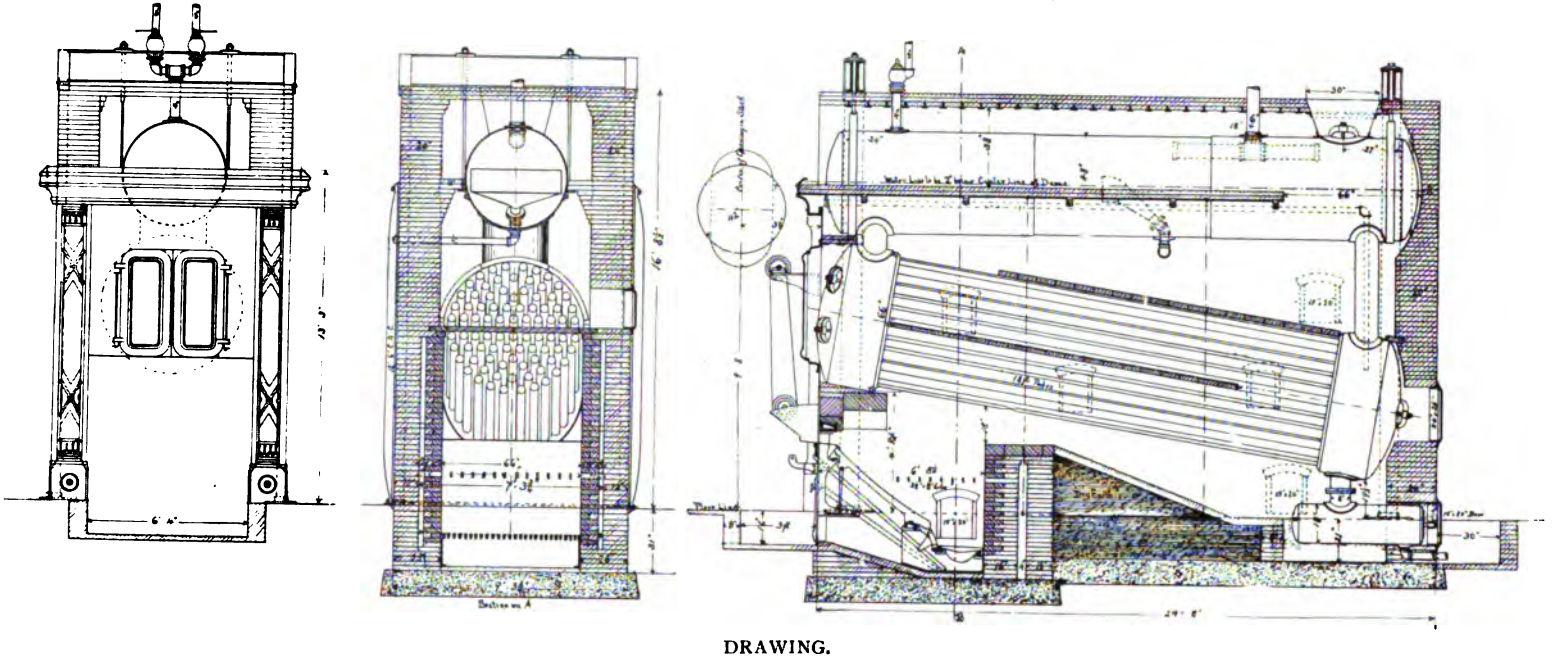

DRAWING.

Showing Detailed Setting of One 150 H. P. Wood Water Tube Boiler, including application of Brightman Stoker.

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the weight of a column of external air as high as the chimney, as found above. by the weight of one cubic foot of the hot gas. If we subtract from this the height of the chimney the difference is the height of the head.

In practice, the velocity of the discharge of the gas is greatly diminished by the resistance opposed by fire grate and layer of fuel to the entrance of air, also by the skin friction of stack and tubes in boiler.

Head in Inches of Water.

Thos. Box, (A Practical Treatise on Heat), says: "For the purpose of calculation this head may be represented in inches of water, thus the density of air at 62° being $\frac{1}{820}$th that of water, and at 552° $\frac{1}{1640}$th; then for a column 80 feet or 960 inches high, we will have $\frac{960}{820} = 1.17$ inch, and $\frac{960}{1640} = .585$ inch respectively; and the difference is 1.17 inch — .585 inch = .585 inch of water.

Assuming a fixed or standard temperature for the chimney at 552° we have in the table the equivalent differences of pressure in inches of water for different heights of chimney.

Height of Chimney in Feet.	Draught Power in Inches of Water.	Height of Chimney in Feet.	Draught Power in Inches of Water.
10	.073	80	.585
20	.146	90	.657
30	.219	100	.730
40	.292	120	.876
50	.365	150	1.095
60	.438	175	1.277
70	.511	200	1.460

The following table shows the power of the draught in the chimney at different internal temperatures, of a chimney 80 feet high, 2 feet 9 inches diameter, with a flue 100 feet long from the furnace to foot of chimney.

Temp. of Air in Chimney.	Draught in Inches of Water.	Pounds of Coal per sq. ft. Chimney Space.
192°	.234	120
322°	.390	150
452°	.500	168
582°	.585	180
712°	.650	188
1102°	.780	195

Thos. Box, (A Treatise on Heat), gives the following formula for determining the quantity of air discharged at 62,° temperature under 30" of the Barometer, as:

$$C = D^2 \times \sqrt{P} \times 21.64.$$

Where C = Cu. ft. discharged per minute.
D = diameter of the orifice in inches.
P = pressure in inches of water.

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POWER HOUSE MICHIGAN ASYLUM FOR THE INSANE, KALAMAZOO, MICH.

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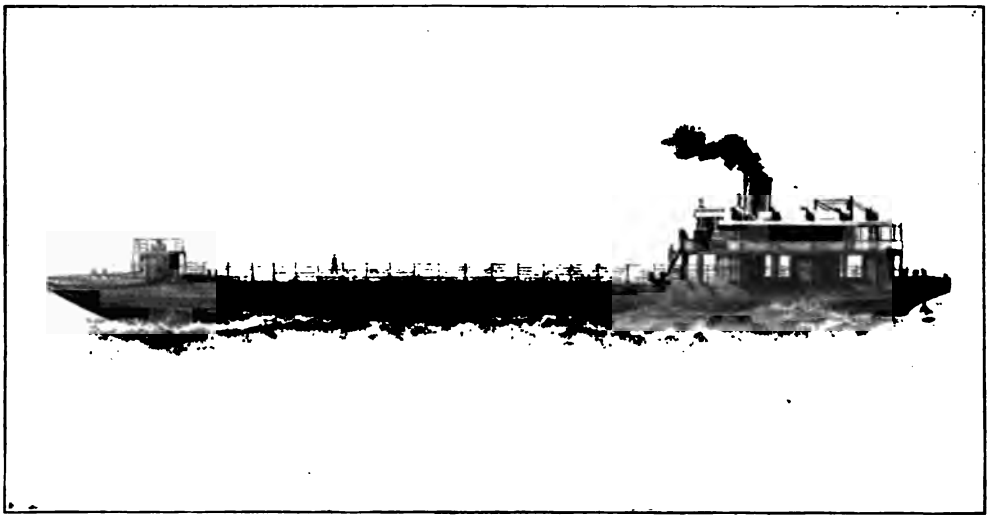

WHALEBACK "SAMUEL MATHER" HAS TWO SCOTCH BOILERS 12 FT. X 13 FT.

Kent gives: "Multiply the height above grate in feet by .0075 and the product is the draught power in inches of water."

R. H. Thurston (A Manual of Steam Boilers), says: "The size and design of the chimney, the height and area of flue are modified somewhat by its form of proportions and by the character of its interior surfaces. The greater the friction head the less its effectiveness. A chimney of circular section and with a straight uniform flue is better than with any other section or with a less direct flue." Mr. Kent (in Trans. A. S. M. E. 1884), assumes that ordinarily the friction of the flue may be taken as equivalent to a reduction of section 2 inches all around and a square flue section as equivalent to a circular one, of diameter equal to its side. He then compiles the following formulæ:

$$\text{H. P.} = 3.33\ E\ \sqrt{H}.$$

$$E. = \frac{0.3\ \text{H. P.}}{\sqrt{H}} = A - 0.6\ \sqrt{A}.$$

$$s. = 12\ \sqrt{E} + 4.$$

$$d. = 13.54\ \sqrt{E} + 4.$$

$$H. = \left(\frac{0.3\ \text{H. P.}}{E}\right)^2$$

in which H. P. = horse-power; H = height of chimney in feet; E = effective area, and A = actual area in square feet; s = side of square chimney, and d = diameter round chimney in inches.

The table is calculated by means of these formulæ:

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SIZES OF CHIMNEYS FOR STEAM BOILERS.

Round Chimney, Diam, in.	18.	21.	24.	27.	30.	33.	36.	39.	42.	48.	54.	60.	66.	72.	78.	84.	90.	96.
Square Chimney Side, in.	16.	19.	22.	24.	27.	30.	32.	35.	38.	43.	48.	54.	59.	64.	70.	75.	80.	86.
Area Square Feet.....	1.77	2.41	3.14	3.98	4.91	5.94	7.07	8.30	9.62	12.57	15.90	19.64	23.76	28.27	33.18	38.48	44.18	50.27
Eff. Area Sq. Feet	.97	1.47	2.08	2.78	3.58	4.47	5.47	6.57	7.76	10.44	13.51	16.98	20.83	25.08	29.73	34.76	40.19	46.01
Height in Feet.	Commercial Horse-Power.																	
50	23	35	49	65	84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
60	25	38	54	72	92	115	141	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
70	27	41	58	78	100	125	152	183	216	.....	.....	.....	.....	.....	.....	.....	.....	.....
80	.....	.....	62	83	107	133	163	196	231	311	363	505	.....	.....	.....	.....	.....	.....
90	.....	.....	.....	.....	113	141	173	208	245	330	427	536	658	792	.....	.....	.....	.....
100	.....	.....	.....	.....	.....	.....	182	219	258	348	449	565	694	835	995	1163	1314	1537
110	.....	.....	.....	.....	.....	.....	.....	.....	271	365	472	593	728	876	1038	1214	1415	1616
125	.....	.....	.....	.....	.....	.....	.....	.....	.....	389	503	632	776	934	1107	1294	1496	1720
150	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	551	692	849	1023	1212	1418	1639	1876
175	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	748	918	1105	1310	1531	1770	2027
200	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	981	1181	1400	1637	1893	2167

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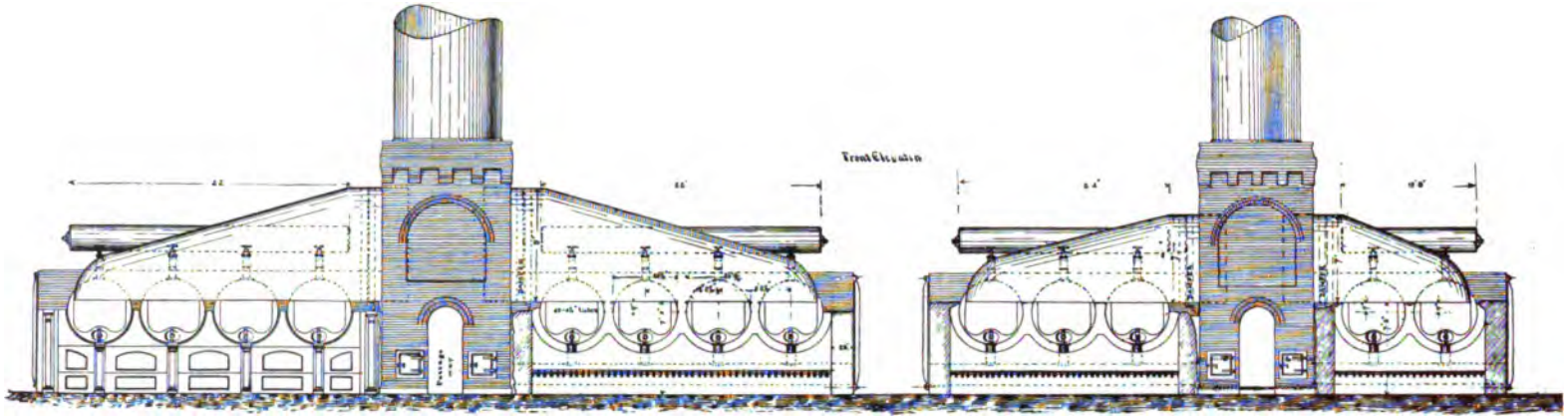

DRAWING.

Four Batteries of Thirteen Boilers, built and erected for Kentucky Union Lumber Company, Clay City, Ky.

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The length of flue leading to the stack changes the intensity of the draught. Thos. Box gives the following table of the power of a chimney 60 feet high, 2 feet 9 inches square, with flues of different lengths:

Length of Flue in Feet.	H. P.	Length of Flue in Feet.	H. P.
50	107.6	800	56.1
100	100.	1000	51.4
200	85.3	1500	43.3
400	70.8	2000	38.2
600	62.5	3000	31.7

PLANT OF SAGINAW MANUFACTURING COMPANY, SAGINAW, MICH.
OPERATED BY THREE 200 H. P. EACH, WOOD WATER TUBE BOILERS.

Prof. Thurston (A Manual of Steam Boilers), says: Mr. Lowe, a builder of large experience, finds the following good proportions for stationary boilers, presumably allowing about 30 pounds of water per hour and 15 square feet heating surface per horse-power:

Height in Feet, - -	50	60	70	80	90	100	110	120
Sq. In. Area per H. P. -	9	8.67	8.34	8.01	7.68	7.35	7.02	6.69
Height in Feet, - -	130	140	150	160	170	180	190	200
Sq. In. Area per H. P. -	6.36	6.03	5.70	5.37	5.04	4.71	4.38	4.05

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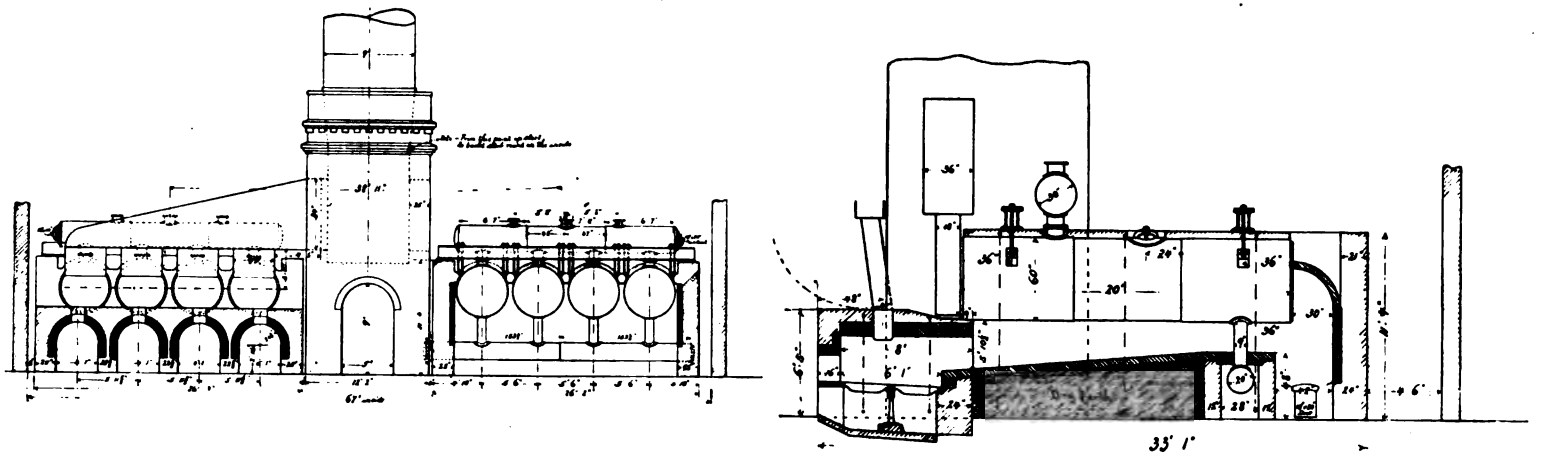

DRAWING.

Two Batteries of Eight Boilers as built and erected for St. Anthony Lumber Company, Whitney, Ontario, showing application of Refuse Burning Furnace.

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In the construction of brick stacks the first and important factor is a firm foundation, as any settling will always be unequal and throw the stack out of perpendicular. The thickness of brickwork should be usually one brick (8 or 9 in.) for 25 feet from top, increasing one-half brick for each 25 feet from top downwards. If the inside diameter exceed 5 feet 6 inches the top thickness should be 1½ bricks, or greater, according to the diameter. We present the dimensions of a large chimney of note, believing the data may be found of interest, as well possibly as instructive, to those designing or contemplating the building of large chimneys:

Dimensions of Stack.

CENTRAL CITY SOAP COMPANY, JACKSON, MICH.
USERS OF WOOD WATER TUBE BOILER.

ST. ROLLOX CHEMICAL WORKS CHIMNEY, GLASGOW.

Messrs. Chas. Tennant & Co.'s Chimney, projected by the late W. J. Macquorn Rankine, C. B., L. L. D., designed by L. D. B. Gordon, and built by the late Mr. McIntyre, ranks second in height, being in—

Height from foundation to top, - - -	455 ft. 6 in.
" " ground surface to top, - -	436 ft. 6 in.
Outside diameter at foundation, - - -	50 ft. 0 in.
" " ground surface, - -	40 ft. 0 in.
" " top, - - - - -	13 ft. 6 in.

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CHICAGO BEECH HOTEL, CHICAGO, ILL. SUPPLIED WITH 400 H. P. OF BOILERS.

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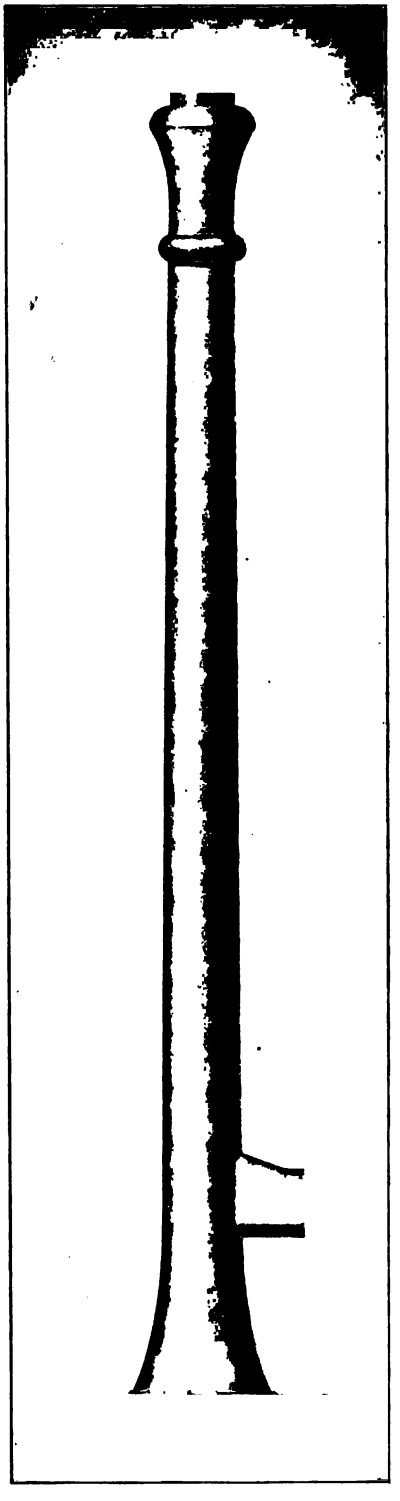

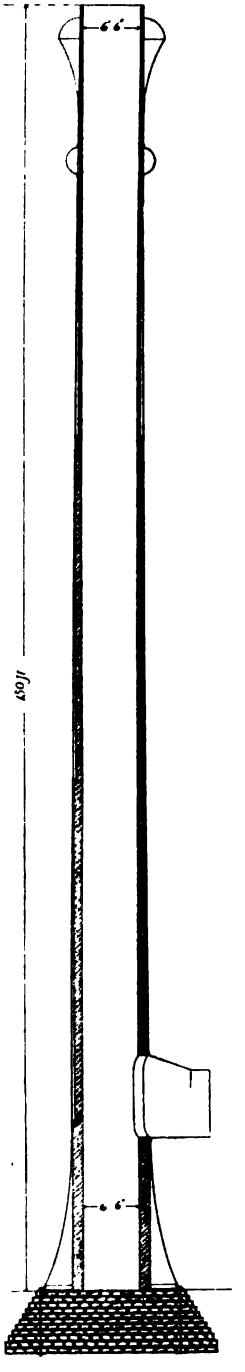

SELF-SUSTAINED IRON STACK LINED WITH FIRE-BRICK.

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It has an inner cone of the following dimensions:

Height of inner cone from foundation to top,	263 ft. 0 in.
" " " " ground sur. to top,	243 ft. 0 in.
Inner cone, inside diameter at foundation, -	12 ft. 0 in.
" " " " top, - -	13 ft. 6 in.

The use of the inner cone is to protect the principal stack from various kinds of gases. No piles were driven in the foundation, it being founded on a bed of concrete 15 ft. thick, on top of the rock, the upper surface of the concrete, the better to resist any downward pressure, being finished at right angles to the line of principal shaft, which inclines inward for a considerable height.

The outline of chimney, it may be said, is taken from the Eddystone lighthouse, or the natural form which a chain would assume in being stretched from a height to a point on the ground beyond that of its upper end.

The stack illustrations which appear are indicative of modern practice in brick chimney design, and the dimensions as given represent our practice. We illustrate also a type of iron chimney, which we are building in all sizes. The self-sustained chimney has many features over a brick one, some of which are: lower cost, being good conductors of lightning and if they become out of perpendicular they can be easily straightened without any damage or risk. They never leak and are very durable. These stacks are at once ornamental, and may be lined half way up or the entire length as desired.

The shell of the chimney is made of iron or steel plate strongly riveted and forming a continuous shell from base to top. It is riveted at the bottom to a heavy cast-iron foundation plate and ring, which is anchored to the foundation by anchor bolts.

STEAMSHIP "L. R. DOTY."
HAS TWO 12 1-2 FT. X 12 1-2 FT. SCOTCH MARINE BOILERS, ALLOWED 170 LBS. PRESSURE.

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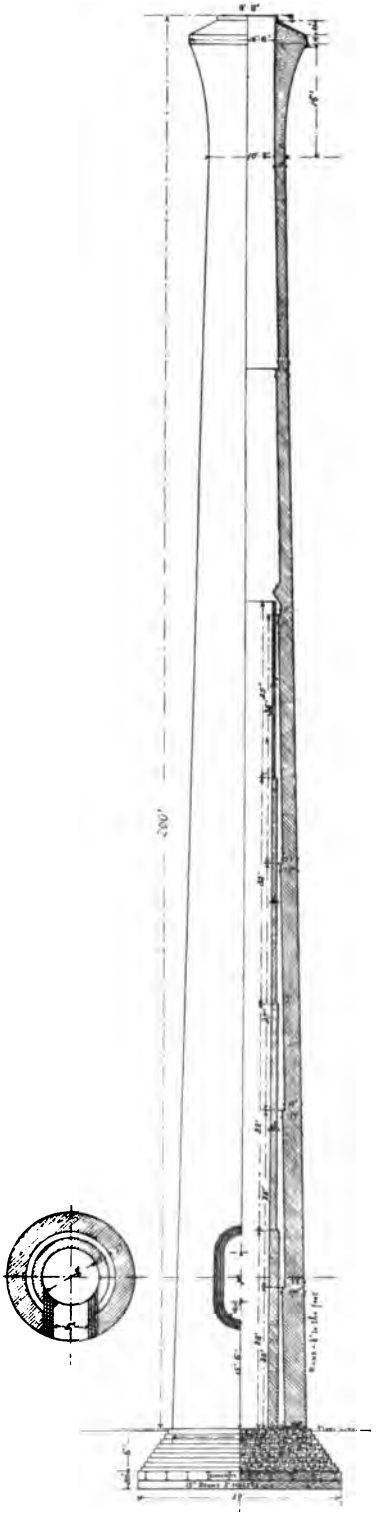

MODERN BRICK CHIMNEY.

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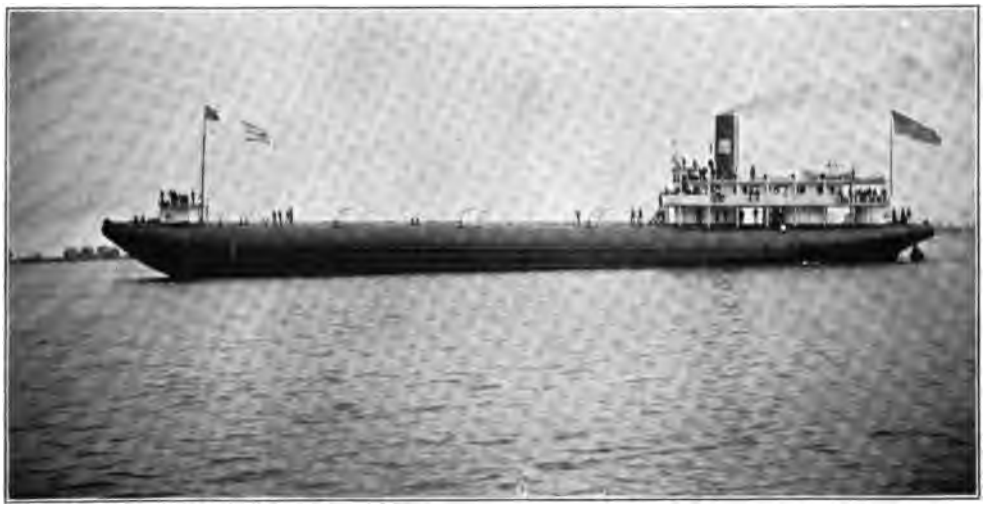
WATER AND ITS IMPURITIES.

WATER is composed, by volume, of oxygen 1 part, hydrogen 2 parts, or by weight, 88.9 parts oxygen, 11.1 parts hydrogen. It is slightly compressible at the rate of $\frac{1}{100}$ of an inch in 18.10 feet by each 15 lbs. per square inch pressure. When pressure is removed its elasticity restores its original bulk. It has a greater solvent power than any other known liquid, and it is due to its absorbent power that it is rarely found pure or free from foreign substances in solution. Like other liquids, it transmits pressure equally in all directions, unchanged and without loss of power.

Weight of gallon and a cubic foot.

Water is 8.15 times heavier than air. A standard United States gallon of fresh water weighs 8⅓ lbs. and contains 231 cu. in. A cu. ft. weighs 62½ lbs. at its greatest density, 39.2° Fah., contains 1728 cu. in., or about 7½ gallons. Under atmospheric pressure it boils at 212° Fah., and freezes at 32° Fah. When evaporated into steam or frozen into ice, water



WHALEBACK STEAMSHIP "JOHN B. TREVOR."
EQUIPPED WITH TWO 12 FT. X 13 FT. SCOTCH BOILERS.

gives up nearly all it contains in solution, so that steam and ice are practically pure. One cubic foot of water expanded into steam becomes 1728 cu. ft. at atmospheric pressure.

As water expands when freezing, ice is lighter than water, having a specific gravity of 0.916 to that of water called unity. The solvent property of water becomes greater (except in a few cases) as the temperature increases, so that in a hot saturated solution most of the mineral salts will be deposited in a crystaline form on cooling.

Water can be freed from substances held in mechanical suspension by filtration, but the filter does not remove those chemically combined with it, as some

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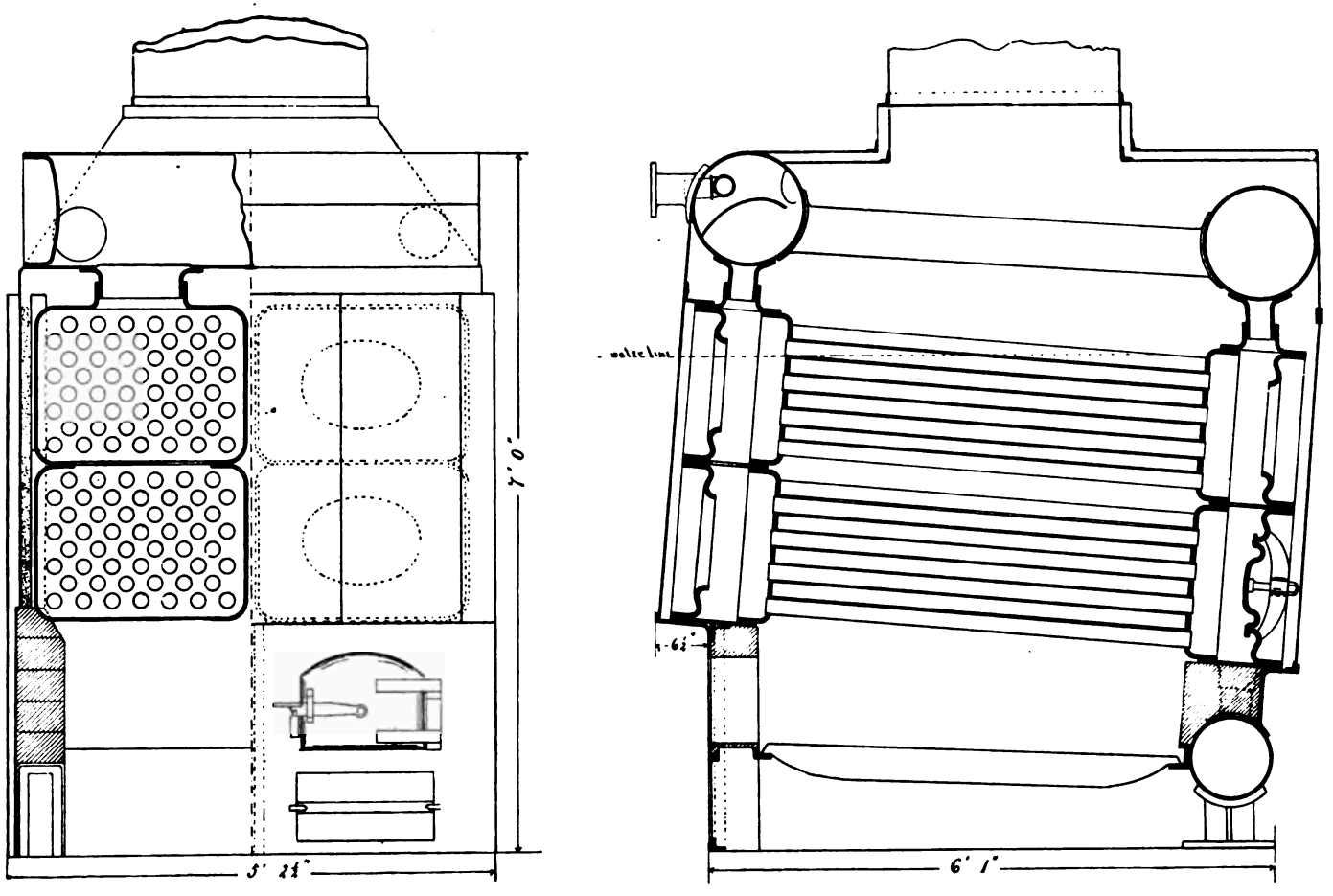

DRAWING.

The Wickes Marine Water Tube Boiler.

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believe. It is therefore apparent that water may be clear and palatable to the taste, as most spring waters are, and at the same time contain mineral impurities very detrimental for steam purposes. To find the pressure in pounds per sq. in. of a column of water, multiply the height in feet by .434. Approximately every foot of elevation is equal to ½ lb. pressure per sq. in. This allows for ordinary friction. The mean pressure of the atmosphere is usually estimated at 14.7 lbs. per sq. in., so that with a perfect vacuum it will sustain a column of mercury 29.9 inches, or a column of water 33.9 feet high.

Pressure of Water.

The following analyses of water taken from various localities are those made by the Keystone Chemical Company:

GRAINS PER U. S. GALLON (231 CUBIC FEET).

ANALYSES OF WATER.	Lime and Magnesia Carbonates.	Lime and Magnesia Sulphates.	Sodium Chloride. (Salt).	Iron Oxide, Carb. Sulph., etc.	Volatile and Organic Matter.	Inorganic Matter.	Organic and Volatile Matter.	Total Solids in Grains.
Albany, N. Y., City Supply	.....	.....	.....	.....	.....	8.47	2.31	10.78
Boston, City Supply, Cochit'te	.....	.....	.....	.....	.....	2.40	0.71	3.11
Buffalo, N. Y., Lake Erie	5.66	3.32	0.58	.....	0.18	.....	.....	9.74
Chicago, Lake Michigan	.....	.....	.....	.....	.....	9.66	1.18	10.74
Girard, O. (River)	6.18	3.72	2.93	0.71	1.76	.....	.....	15.30
Milwaukee, Wis. (River)	6.23	4.67	1.76	20.14	6.50	.....	.....	39.30
Mansfield, O., Water Works	9.93	5.52	1.17	1.98	4.30	.....	.....	22.90
New York City (Croton R.)	.....	.....	.....	.....	.....	6.20	0.67	6.87
Peoria, Ill	5.47	6.43	5.85	2.05	4.90	.....	.....	24.50
Pittsburgh, Allegheny R.	0.37	3.78	0.58	0.37	1.50	.....	.....	6.60
Pittsburgh, Monongahela R.	1.06	5.12	0.64	0.78	3.20	.....	.....	10.80
Philadelphia, Schuylkill R.	.....	.....	.....	.....	.....	2.30	1.20	3.50
Rockford, Ill	25.98	.....	1.42	0.07	0.67	.....	.....	28.14
Syracuse, N. Y., Reservoir	.....	.....	.....	.....	.....	12.13	1.23	13.25
Utica, N. Y	.....	.....	.....	.....	.....	5.50	0.96	6.46
Youngstown, O., Mahoning R.	.....	.....	.....	.....	.....	10.00	1.50	11.50
Appleton, Wis., Fox River	7.04	1.46	trace	trace	1.70	.....	.....	10.20
Blue Island, Ill., Calumet R.	5.55	3.35	0.88	2.62	3.70	.....	.....	16.10
Bay City, Mich., Bay	8.47	10.36	20.48	1.15	8.74	.....	.....	49.24
Bay City, Mich., River	4.84	33.66	126.78	3.00	10.92	.....	.....	179.20
Columbus, O	20.76	11.74	7.02	0.58	6.50	.....	.....	46.60
Cincinnati, O., River	3.88	0.78	1.79	.....	trace	.....	.....	6.73
Decatur, Ill., City Supply	15.66	1.32	2.34	trace	2.88	.....	.....	22.20
Fort Wayne, Ind	8.78	6.22	3.51	1.59	10.98	.....	.....	31.08
Finley, O	18.22	6.39	1.17	0.31	6.27	.....	.....	32.96
Flint, Mich., City Supply	11.06	6.32	0.88	0.04	3.30	.....	.....	21.60
Fond du Lac, Wis., City Supply	9.44	9.52	6.54	trace	4.20	.....	.....	29.70
Kansas City, Mo	8.10	4.20	1.76	1.04	5.60	.....	.....	20.70
Kenosha, Wis., City Supply	14.04	12.02	0.88	trace	9.26	.....	.....	40.60
Lima, O	5.28	5.82	9.95	0.55	7.50	.....	.....	28.60
Muncie, Ind., M. P. Co	15.92	0.72	0.59	0.17	2.70	.....	.....	20.10
Madison, Wis., U. of W	9.20	trace	trace	trace	2.80	.....	.....	12.00
Peoria, Ill., City Supply	17.80	3.42	1.76	trace	3.82	.....	.....	26.80
Springfield, Ill	12.17	5.03	trace	trace	2.10	.....	.....	19.30

Professor R. H. Thurston says: Incrustation and sediment are deposited in boilers, the one by the precipitation of mineral or other salts previously held in

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solution in the feed water, the other by the deposition of mineral insoluble matters, usually earths carried into it in suspension or mechanical admixture.

The animal and vegetable oils and greases carried over from the condenser or feed water-heater are also very likely to cause trouble. Only mineral oils should be permitted to be thus introduced, and that in a minimum quantity. Both the efficiency and the safety of the boiler are endangered by any of these deposits.

The impurities are usually either calcium carbonate or calcium sulphate, or a mixture. Organic matters often harden the mineral scales, and make them more difficult of removal.

TRAIN LOAD OF BOILERS EN ROUTE TO PACIFIC COAST FOR 5,000 TON STEAMER "EVERETT."

Effect of Scale.

The effect of incrustation and of deposits of various kinds is to enormously reduce the conducting power of heating surfaces, so much so that the power as well as the economic efficiency of a boiler may become very greatly reduced below that for which it is rated, and the supply of steam furnished by it may become wholly inadequate to the requirements of the case.

It is estimated that a sixteenth of an inch thickness of hard scale on the heating surface of a boiler will cause waste of nearly one-eighth its efficiency, and the waste increases as the square of thickness.

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STEAMER "C. H. BRADLEY."
EQUIPPED WITH TWO 11 1-2 FT. X 12 FT. SCOTCH BOILERS, ALLOWED 160 LBS. PRESSURE.

Land boilers are subject to incrustation by the carbonate and other salts of lime, and by the deposit of sand or mud mechanically suspended in the feed water.

It has been estimated that the annual cost of operation of locomotives in limestone districts is increased $750 by deposits of scale.

The only positive and certain remedy for incrustation and sediment once deposited is periodical removal by mechanical means, at sufficiently frequent intervals to insure against injury by too great accumulation. Between times some good may be done by special expedients suited to the individual case. No one process and no one antidote will suffice for all cases.

Sediment and incrustation sometimes produce the effect of low water in boilers, even where the surfaces effected are far below the surface of the water.

Antidote. Where carbonate of lime exists sal ammoniac may be used as a preventative of incrustation, a double decomposition occurring, resulting in the production of ammonium carbonate and calcium chloride, both of which are soluble, and the first of which is volatile. The bicarbonate may be in part precipitated before use by heating to the boiling point and thus breaking up the salt and precipitating the insoluble carbonate. Solutions of caustic lime and metallic zinc act in the same manner. Waters containing tannic acid and the juices of oak, sumach, logwood, hemlock and other woods are sometimes

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used, but are apt to injure the iron of the boiler, as may acetic or other acid contained in the various saccharine matters often introduced into the boiler to prevent scale, and which also make the lime sulphate scale more troublesome than when clean.

Organic matters should never be used.

The sulphate scale is sometimes attacked by the carbonate of soda, the products being a soluble sodium sulphate and a pulverulent insoluble calcium carbonate, which settles to the bottom, like other sediments. Barium chloride acts similarly, producing barium sulphate and calcium chloride.

All the alkalies are used at times to reduce incrustations of calcium sulphate, as is pure crude petroleum, the tennate of soda, and other chemicals.

Marine boilers have been effectively treated for the prevention of scale by introducing sheet zinc or zinc in balls. Care must be taken to form a perfect metallic connection between the zinc and the boiler. A surface of zinc 25 to 50 sq. in. per ton of water contained in the boiler and per month is usually found ample.

REAR VIEW, SHOWING STACK ON IRON BASE, HEATER, ETC., AS LOCATED IN SAGINAW MANUFACTURING COMPANY'S PLANT.

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CHARACTER AND PROPERTIES OF STEAM.

ON account of the inefficient character of the steam engine in its early form, considered both in a thermodynamic and mechanical sense, little thought was given to the character of the steam delivered to the engine. The importance of correctly determining the quality of steam is, however, today realized, since it is known that the percentage of water carried over in the steam in the form of vapor or drops of water, may be large, and such water is an inert quantity so far as its work-producing power is concerned, while its presence in the cylinder frequently results in a serious wreckage of the engines in a mechanical sense.

POWERFUL ROCK DIGGING DREDGE, BUILT FOR R. J. CRAM, DETROIT, MICH.

Today, in summing up the functions which go to make up the efficiency of a steam boiler, that of the quality of the steam is one of the paramount, and no steam boiler test where the quality of steam is not at least approximately determined can be accepted as giving any reliable measure of the efficiency of a boiler.

Definitions. Professor R. C. Carpenter gives the following definitions: Steam occurs in two different conditions: 1, saturated; 2, superheated.

1. SATURATED STEAM. This can exist only in contact with the water from which it was generated, although the quantity of water present may be very small. Saturated steam of any pressure is at the lowest temperature and pos-

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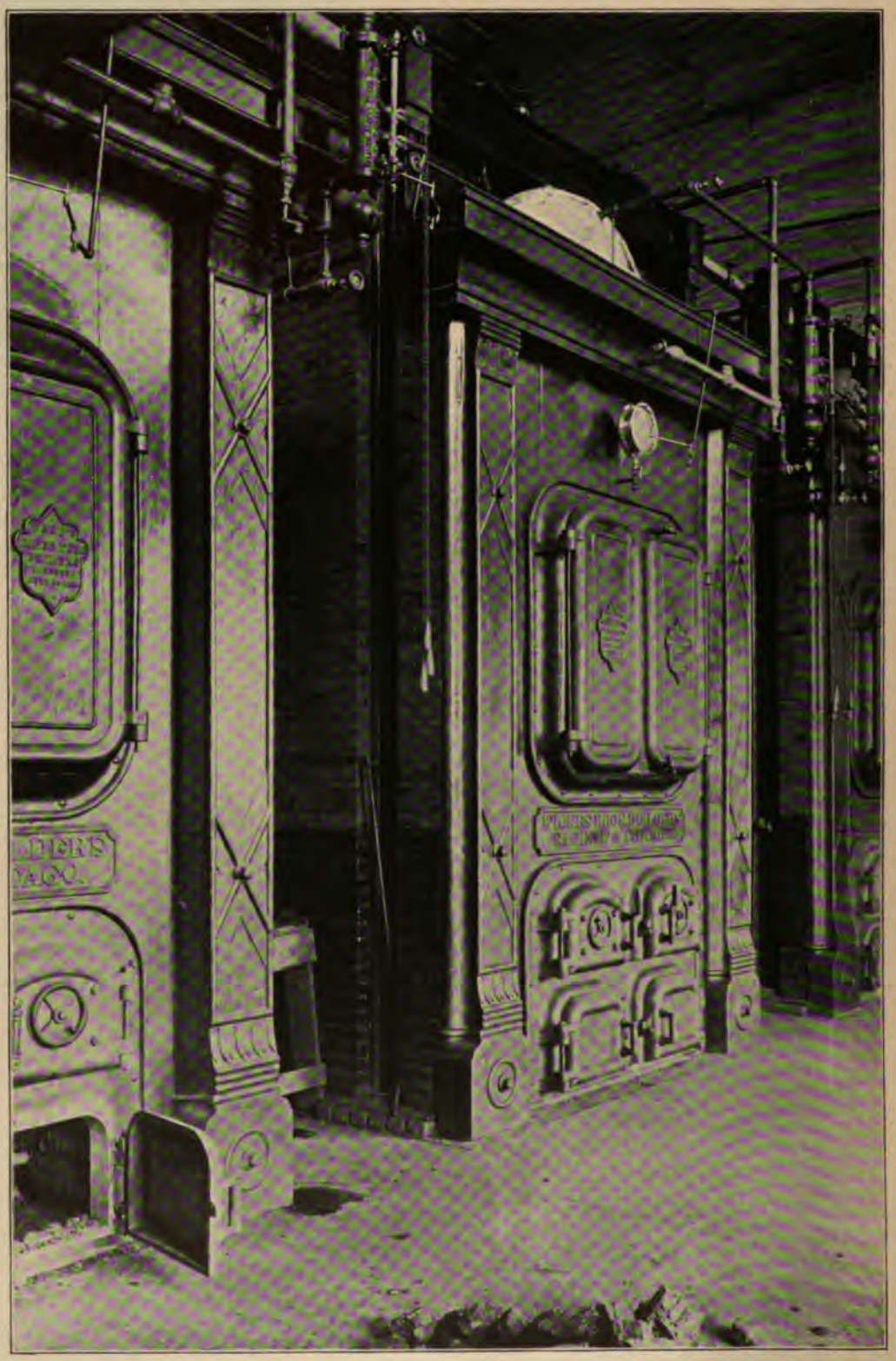

BOILER ROOM INTERIOR SAGINAW WATER WORKS.

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sesses the least specific volume and the greatest density consistent with that pressure. The slightest decrease in temperature results in partial condensation, forming what is termed moist or wet steam, in distinction from dry steam. Thus, saturated steam may be either wet or dry.

Quality. The percentage of dry steam in a mass of wet steam is termed its *quality*. It is in any case the *total heat* in a pound of the sample steam, less the *heat of the liquid*, divided by the total *latent heat of evaporation* of one pound of dry steam at the same pressure.

2. SUPERHEATED STEAM cannot exist in contact with the water from which it was generated. Its temperature is higher, its specific volume greater, and its density less than saturated steam of the same pressure.

STEAM YACHT "WANEKA."
FITTED WITH 100 H. P. WATER TUBE BOILER, ALLOWED 250 LBS. PRESSURE.

There are three different methods of determining the amount of moisture in steam, the best known of which is by calorimetry, and there are a variety of different calorimeters used for this purpose. The barrel is one of the best known and simplest types, and consists, usually, of an ordinary oil barrel resting on a pair of scales. A sample of steam is drawn from the main steam pipe, care being taken to obtain the sample from the center of the pipe, in order that it may be a fair average of the steam to be tested, and conveyed by a hose to the calorimeter. In the use of the instrument, water is

The Barrel Calorimeter.

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first admitted to the barrel and the weight and temperature accurately determined. The hose is then heated by permitting steam to blow through it into the air; steam is then shut off, the end of the hose is submerged in the water of the calorimeter, and steam turned on and the pressure noted until the temperature of the condensing water is about 110° F. The hose should be wired to the end of a paddle, by means of which it can be held down into the barrel, and by the use of the paddle the water thoroughly stirred. The hose is then removed, the water vigorously stirred, the final weight and temperature taken.

From the data obtained and the following formula, the calculations can be easily made:

Let W equal original weight of water in calorimeter.
" w " weight of water added by heating.
" t_1 ". temperature of condensing water in calorimeter cold.
" t_2 " temperature of water in calorimeter after heating.
" t " temperature of steam at observed pressure.
" x " quality.
" L " latent heat of steam at observed pressure.
" D " degree of superheat.

$$x = \frac{W(t_2 - t_1)}{wL} - \frac{(t - t_2)}{L}$$

When x is greater than unity the steam is superheated and the degree of superheat

$$D = \frac{(x - 1) L}{0.48}$$

when .48 = specific heat of steam. When x is less than unity, percentage of moisture in steam = 100 (1-x).

Directions for Use of the Barrel Calorimeter Apparatus: Thermometer reading to $\frac{1}{5}$ degree F., range 32° to 212°; scales reading to $\frac{1}{20}$ of a pound; barrel provided with means of filling with water and emptying; proper steam connections; steam gauge or thermometer in main steam pipe.

1. Calibrate all apparatus.

2. Fill barrel with 360 pounds of water and heat to 130 degrees by steam; waste this and make no determination for moisture. This is to warm up the barrel.

3. Empty the barrel, take its weight, add quickly 360 pounds of water, and take its temperature.

4. Supply steam through a hose, which is removed as soon as water rises to a temperature of 110° F., weigh with the hose removed from the barrel, stir the water while taking temperatures.

5. Take five determinations and compute results as explained.

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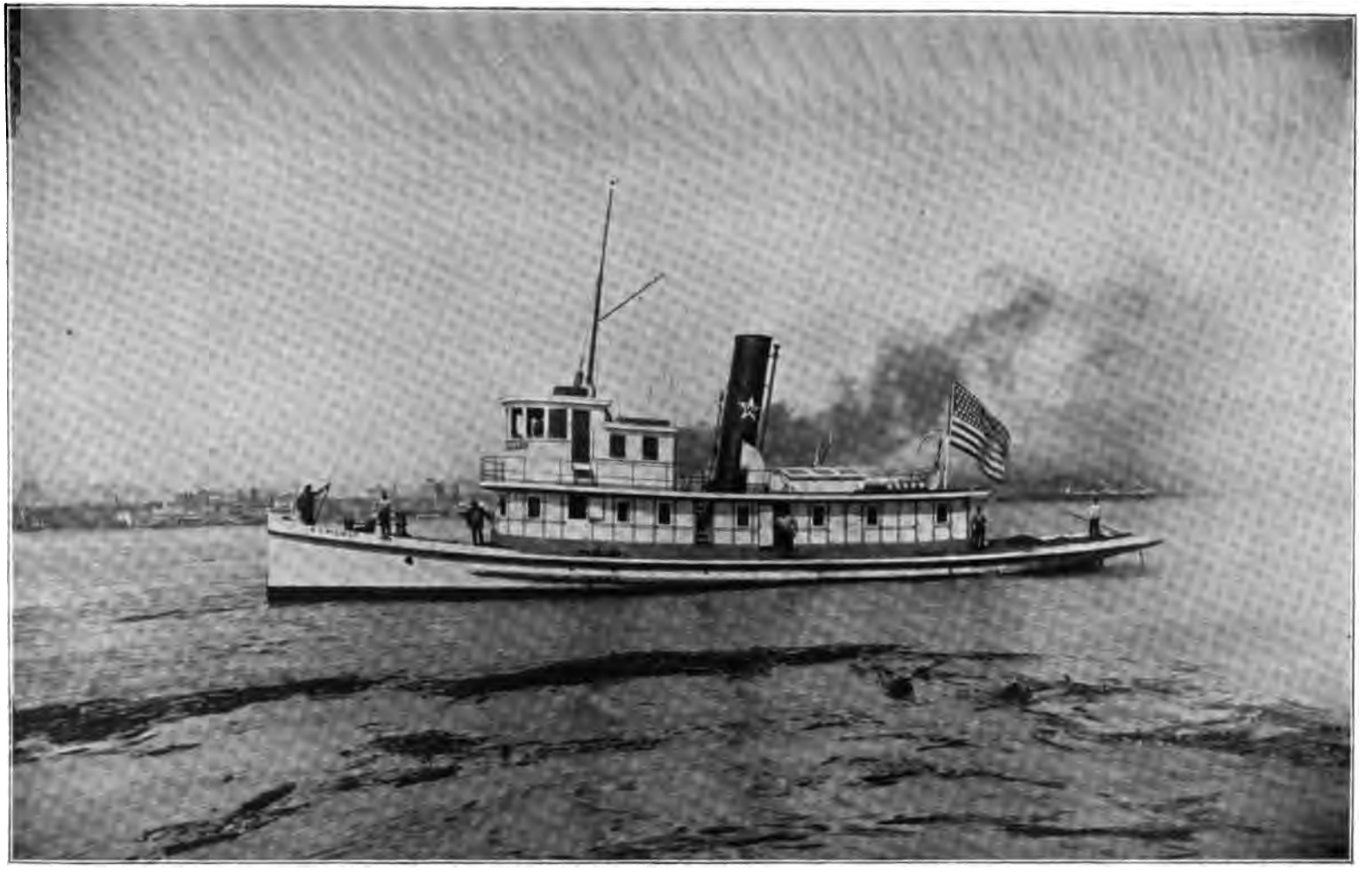

STEEL TUG "W. G. WILMOT."

LOCATED AT NEW ORLEANS. THE LARGEST HARBOR TUG ON THE GULF. SCOTCH BOILER 12 1-2 FT. X 12 FT. PRESSURE 160 LBS.

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From a long series of tests and experiments made with the **Wood Water Tube Boiler,** and working under a range of horse-power fluctuating from nominal to 60 per cent. above, it was found that the steam was dry and saturated, as in the most extreme case there was to be found no more than .32 of 1 per cent. moisture.

These excellent results are undoubtedly due to the immense disengaging surface, together with the rapid and smooth circulation caused by our neck construction, which means an entire absence of that geyser-like action of water which is so common, and which invariably means wet steam.

SAGINAW MILLING COMPANY.
EQUIPPED WITH WOOD WATER TUBE BOILERS.

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PROPERTIES OF SATURATED STEAM.

(From Chas. T. Porter's Treatise on the Richards Steam Engine Indicator).

Pressure above Zero.	Temperature.	Sensible Heat above Zero.	Latent Heat.	Total Heat above Zero.	Weight of One Cubic Foot.
Pounds per square inch.	Fahr., Deg.	Fahr., B. T. U.	B. T U.	Fahr., B. T. U.	Pounds.
1	102.00	102.08	1042.96	1145.05	.0030
2	126.26	126.44	1026.01	1152.45	.0058
3	141.62	141.87	1015.25	1157.13	.0085
4	153.07	153.39	1007.22	1160.62	.0112
5	162.33	162.72	1000.72	1163.44	.0137
6	170.12	170.57	995.24	1165.82	.0163
7	176.91	177.42	990.47	1167.89	.0189
8	182.91	183.48	986.24	1169.72	.0214
9	188.31	188.94	982.43	1171.37	.0239
10	193.24	193.91	978.95	1172.87	.0264
11	197.76	198.49	975.76	1174.25	.0289
12	201.96	202.73	972.80	1175.53	.0313
13	205.88	206.70	970.02	1176.73	.0337
14	209.56	210.42	967.42	1177.85	.0362
15	213.02	213.93	964.97	1178.91	.0387
16	216.29	217.25	962.65	1179.90	.0413
17	219.41	220.40	960.45	1180.85	.0437
18	222.37	223.41	958.34	1181.76	.0462
19	225.20	226.28	956.34	1182.62	.0487
20	227.91	229.03	954.41	1183.45	.0511
21	230.51	231.67	952.57	1184.24	.0536
22	233.01	234.21	950.79	1185.00	.0561
23	235.43	236.67	949.07	1185.74	.0585
24	237.75	239.02	947.42	1186.45	.0610
25	240.00	241.31	945.82	1187.13	.0634
26	242.17	243.52	944.27	1187.80	.0658
27	244.28	245.67	942.77	1188.44	.0683
28	246.32	247.74	941.32	1189.06	.0707
29	248.31	249.76	939.90	1189.67	.0731
30	250.24	251.73	938.92	1190.26	.0755
31	252.12	253.64	937.18	1190.83	.0779
32	253.95	255.51	935.88	1191.39	.0803
33	255.73	257.32	934.60	1191.93	.0827
34	257.47	259.10	933.36	1192.46	.0851
35	259.17	260.83	932.15	1192.98	.0875
36	260.83	262.52	930.96	1193.49	.0899
37	262.45	264.18	929.80	1193.98	.0922
38	264.04	265.80	928.67	1194.47	.0946
39	265.59	267.38	927.56	1194.94	.0970
40	267.12	268.93	926.47	1195.41	.0994
41	268.61	270.46	925.40	1195.86	.1017
42	270.07	271.95	924.35	1196.31	.1041
43	271.50	273.41	923.33	1196.74	.1064
44	272.91	274.85	922.32	1197.17	.1088
45	274.29	276.26	921.33	1197.60	.1111
46	275.65	277.65	920.36	1198.01	.1134
47	276.98	279.01	919.40	1198.42	.1158
48	278.29	280.35	918.46	1198.82	.1181
49	279.58	281.67	917.54	1199.21	.1204
50	280.85	282.96	916.63	1199.60	.1227
51	282.09	284.24	915.73	1199.98	.1251
52	283.32	285.49	914.85	1200.35	.1274

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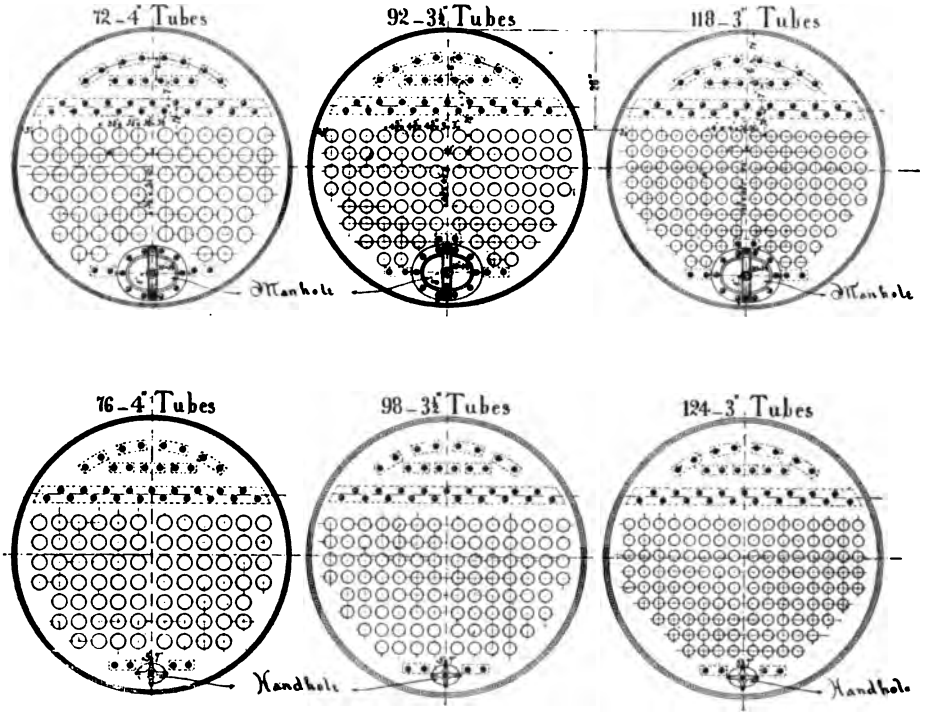
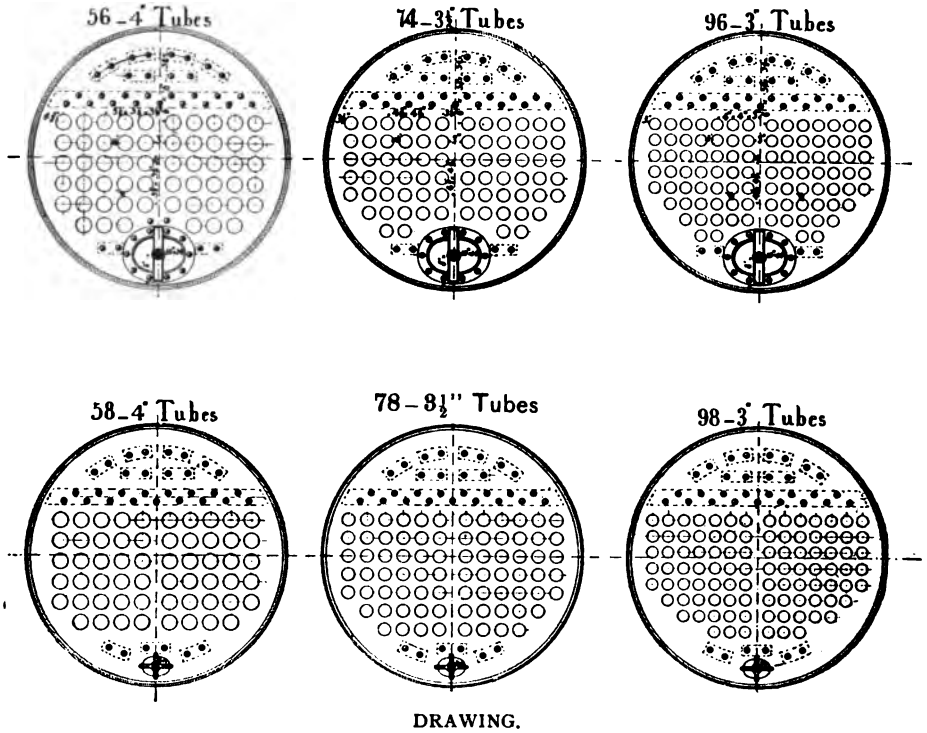


DRAWING.

Showing Layout of Tubes and Braces for 72 Inch Horizontal Tubular Boiler, with Manhole or Handhole in Head.



DRAWING.

Showing Layout of Tubes and Braces for 66 Inch Horizontal Tubular Boiler, with Manhole or Handhole in Head.

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PROPERTIES OF SATURATED STEAM.—Continued.

Pressure above Zero.	Temperature.	Sensible Heat above Zero.	Latent Heat.	Total Heat above Zero.	Weight of One Cubic Foot.
Pounds per square inch.	Fahr., Deg.	Fahr., B. T. U.	B. T. U.	Fahr., B. T. U.	Pounds.
53	284.53	286.73	913.98	1200.72	.1297
54	285.72	287.95	913.13	1201.08	.1320
55	286.89	289.15	912.29	1201.44	.1343
56	288.05	290.33	911.46	1201.79	.1366
57	289.11	291.50	910.64	1202.14	.1388
58	290.31	292.65	909.83	1202.48	.1411
59	291.42	293.79	909.03	1202.82	.1434
60	292.52	294.91	908.24	1203.15	1457
61	293.59	296.01	907.47	1203.48	.1479
62	294.66	297.10	906.70	1203.81	.1502
63	295.71	298.18	905.94	1204.13	.1524
64	296.75	299.24	905.20	1204.44	.1547
65	297.77	300.30	904.46	1204.76	.1569
66	298.78	301.33	903.73	1205.07	.1592
67	299.78	302.36	903.01	1205.37	.1614
68	300.77	303.37	902.29	1205.67	.1637
69	301.75	304.38	901.59	1205.97	.1659
70	302.71	305.37	900.89	1206.26	.1681
71	303.67	306.35	900.21	1206.56	.1703
72	304.61	307.32	899.52	1206.84	.1725
73	305.55	308.27	898.85	1207.13	.1748
74	306.47	309.22	898.18	1207.41	.1770
75	307.38	310.16	897.52	1207.69	.1792
76	308.29	311.09	896.87	1207.96	.1814
77	309.18	312.01	896.23	1208.24	.1836
78	310.06	312.92	895.59	1208.51	.1857
79	310.94	313.82	894.95	1208.77	.1879
80	311.81	314.71	894.33	1209.04	.1901
81	312.67	315.59	893.70	1209.30	.1923
82	313.52	316.46	893.09	1209.56	.1945
83	314.36	317.33	892.48	1209.82	.1967
84	315.19	318.19	891.88	1210.07	.1988
85	316.02	319.04	891.28	1210.32	.2010
86	316.83	319.88	890.69	1210.57	.2032
87	317.65	320.71	890.10	1210.82	.2053
88	318.45	321.54	889.52	1211.06	.2075
89	319.24	322.36	888.94	1211.31	.2097
90	320.03	323.17	888.37	1211.55	.2118
91	320.82	323.98	887.80	1211.79	.2130
92	321.59	324.78	887.24	1212.02	.2160
93	322.36	325.57	886.68	1212.26	.2182
94	323.12	326.35	886.13	1212.49	.2204
95	323.88	327.13	885.58	1212.72	.2224
96	324.63	327.90	885.04	1212.95	.2245
97	325.37	328.67	884.50	1213.18	.2266
98	326.11	329.43	883.97	1213.40	.2288
99	326.84	330.18	883.44	1213.62	.2309
100	327.57	330.93	882.91	1213.84	.2330
101	328.29	331.67	882.39	1214.06	.2351
102	329.00	332.41	881.87	1214.28	.2371
103	329.71	333.14	881.35	1214.50	.2392
104	330.41	333.86	880.84	1214.71	.2413
105	331.11	334.58	880.34	1214.92	.2434
106	331.80	335.30	879.84	1215.14	.2454
107	332.49	336.00	879.34	1215.35	.2475
108	333.17	336.71	878.84	1215.55	.2496
109	333.85	337.41	878.35	1215.76	.2516
110	334.52	338.10	877.86	1215.97	.2537

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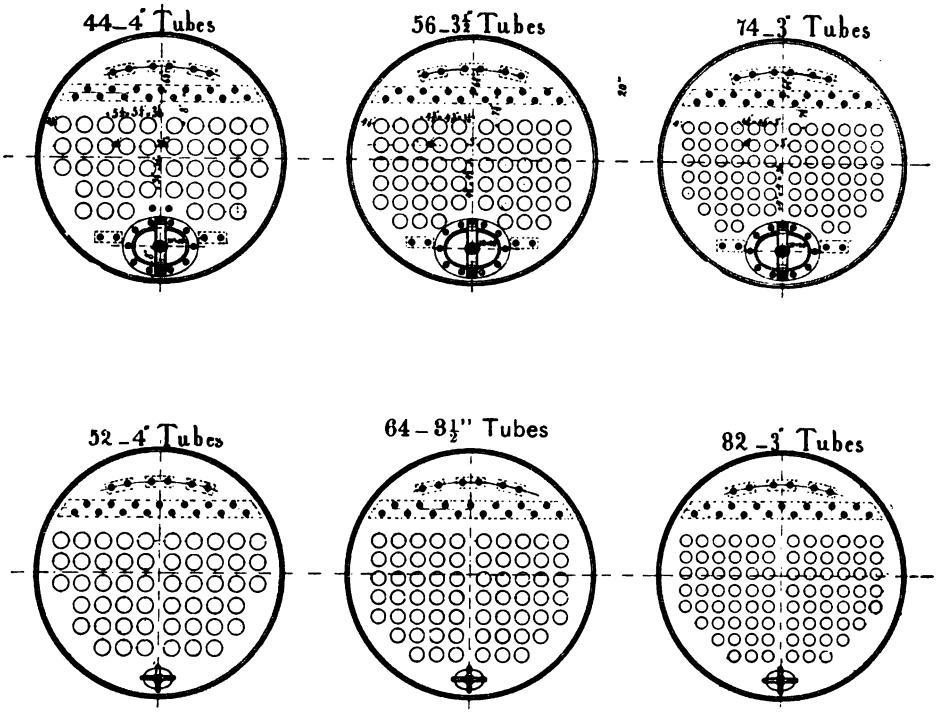
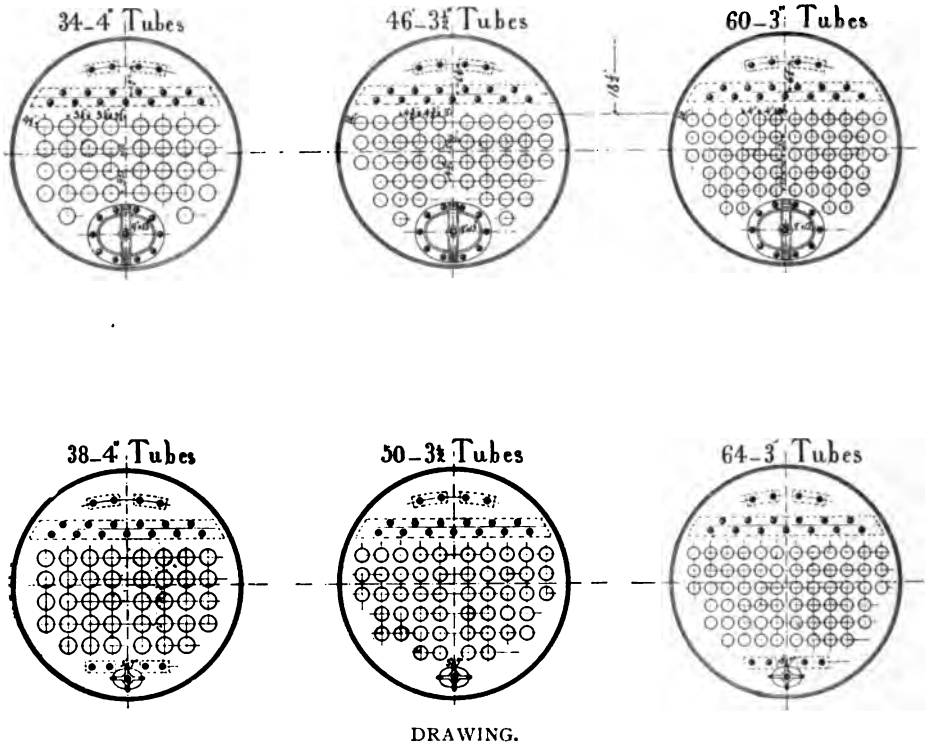


DRAWING.

Showing Layout of Tubes and Braces for 60 Inch Horizontal Tubular Boiler, with Manhole or Handhole in Head.



DRAWING.

Showing Layout of Tubes and Braces for 54 Inch Horizontal Tubular Boiler, with Manhole or Handhole in Head.

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PROPERTIES OF SATURATED STEAM.—Continued.

Pressure above Zero.	Temperature.	Sensible Heat above Zero.	Latent Heat.	Total Heat above Zero.	Weight of One Cubic Foot.
Pounds per square inch.	Fahr., Deg.	Fahr., B. T. U.	B. T. U	Fahr., B. T. U.	Pounds.
111	335.19	338.79	877.37	1216.17	.2558
112	335.85	339.47	876.89	1216.37	.2578
113	336.51	340.15	876.41	1216.57	.2599
114	337.16	340.83	875.94	1216.77	.2619
115	337.81	341.50	875.47	1216.97	.2640
116	338.45	342.16	875.00	1217.17	.2661
117	339.10	342.83	874.53	1217.36	.2681
118	339.73	343.48	874.07	1217.56	.2702
119	340.36	344.14	873.61	1217.75	.2722
120	340.99	344.78	873.15	1217.94	.2742
121	341.61	345.43	872.70	1218.13	.2762
122	342.23	346.07	872.25	1218.32	.2782
123	342.85	346.70	871.80	1218.51	.2802
124	343.46	347.34	871.35	1218.69	.2822
125	344.07	347.97	870.91	1218.88	.2842
126	344.67	348.59	870.47	1219.06	.2862
127	345.27	349.21	870.03	1219.25	.2882
128	345.87	349.83	869.59	1219.43	.2902
129	346.45	350.44	869.16	1219.61	.2922
130	347.05	351.05	868.73	1219.79	.2942
131	347.64	351.66	868.30	1219.97	.2961
132	348.22	352.26	867.88	1220.15	.2981
133	348.80	352.86	867.46	1220.32	.3001
134	349.38	353.46	867.03	1220.50	.3020
135	349.95	354.05	866.62	1220.67	.3040
136	350.52	354.64	866.20	1220.85	.3060
137	351.08	355.23	866.79	1221.02	.3079
138	351.75	355.81	865.38	1221.19	.3099
139	352.21	356.39	864.97	1221.36	.3118
140	352.76	356.96	864.56	1221.53	.3138
141	353.31	357.54	864.16	1221.70	.3158
142	353.86	358.11	863.76	1221.87	.3178
143	354.41	358.67	863.36	1222.03	.3199
144	354.96	359.24	862.96	1222.20	.3219
145	355.50	359.80	862.56	1222.36	.3239
146	356.03	360.85	862.17	1222.53	.3259
147	356.57	360.91	861.78	1222.69	.3279
148	357.10	361.46	861.39	1222.85	.3299
149	357.63	362.01	861.00	1223.01	3319
150	358.16	362.55	860.62	1223.18	.3340
151	358.68	363.10	860.23	1223.33	.3358
152	359.20	363.64	859.85	1223.49	.3376
153	359.72	364.17	859.47	1223.65	.3394
154	360.23	364.71	859.10	1223.81	.3412
155	360.74	365.24	858.72	1223.97	.3430
156	361.26	365.77	858.35	1224.12	.3448
157	361.76	366.30	857.98	1224.28	.3466
158	362.27	366.82	857.61	1224.43	.3484
159	362.77	367.34	857.24	1224.58	.3502
160	363.27	367.86	856.87	1224.74	.3520
161	363.77	368.38	856.50	1224.89	.3539
162	364.27	368.89	856.14	1225.04	.3558
163	364.76	369.41	855.78	1225.19	.3577
164	365.25	369.92	855.42	1225.34	.3596
165	365.74	370.42	855.06	1225.49	.3614
166	366.23	370.93	854.70	1225.64	.3633
167	366.71	371.43	854.35	1225.78	.3652
168	367.19	371.93	853.99	1225.93	.3671

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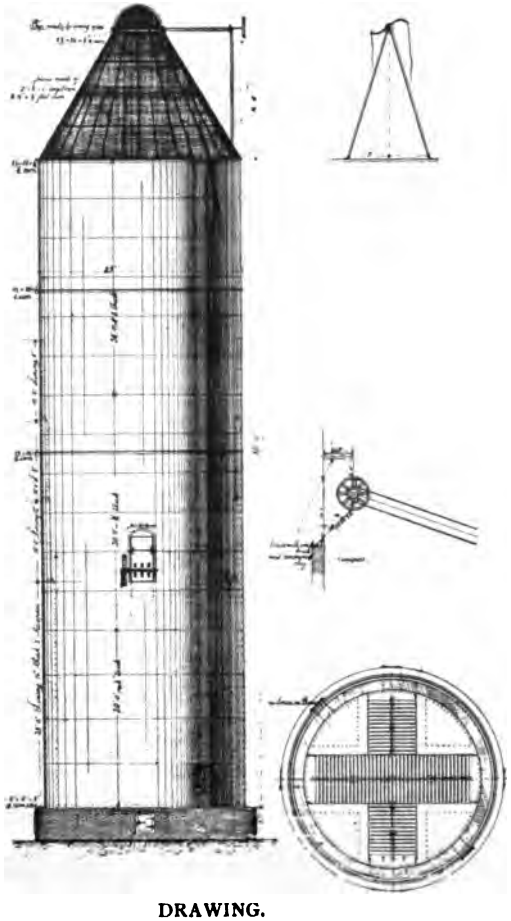
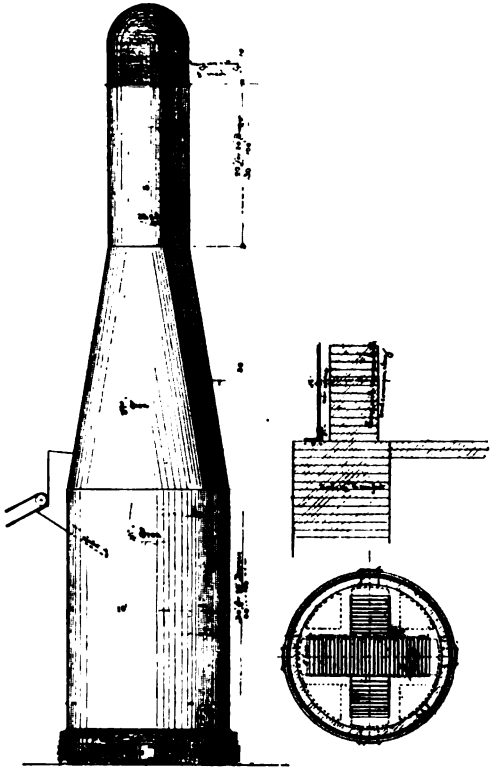


DRAWING.

Straight, Brick Lined, Refuse Burner, 25 Ft. Diameter, 80 Ft. High.



DRAWING.

Bottle Shaped Refuse Burner, Brick Lined.

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PROPERTIES OF SATURATED STEAM.—Continued.

Pressure above Zero.	Temperature.	Sensible Heat above Zero.	Latent Heat.	Total Heat above Zero.	Weight of One Cubic Foot.
Pounds per square inch.	Fahr., Deg.	Fahr., B. T. U.	B. T. U.	Fahr., B. T. U.	Pounds.
169	367.68	372.43	853.64	1226.08	.3690
170	368.15	372.93	853.29	1226.22	.3709
171	368.63	373.42	852.94	1226.37	.3727
172	369.10	373.91	852.59	1226.51	.3745
173	369.57	374.40	852.25	1226.66	.3763
174	370.04	374.89	851.90	1226.80	.3781
175	370.51	375.38	851.56	1226.94	.3799
176	370.97	375.86	851.22	1227.08	.3817
177	371.44	376.34	850.88	1227.23	.3835
178	371.90	376.82	850.54	1227.37	.3853
179	372.36	377.30	850.20	1227.51	.3871
180	372.82	377.78	849.86	1227.65	.3889
181	373.27	378.25	849.53	1227.78	.3907
182	373.73	378.72	849.20	1227.92	.3925
183	374.18	379.19	848.86	1228.06	.3944
184	374.63	379.66	848.53	1228.20	.3962
185	375.08	380.13	848.20	1228.33	.3980
186	375.52	380.59	847.88	1228.47	.3999
187	375.97	381.05	847.55	1228.61	.4017
188	376.41	381.51	847.22	1228.74	.4035
189	376.85	381.97	846.90	1228.87	.4053
190	377.29	382.42	846.58	1229.01	.4072
191	377.72	382.88	846.26	1229.14	.4089
192	378.16	383.33	845.94	1229.27	.4107
193	378.59	383.78	845.62	1229.41	.4125
194	379.02	384.23	845.30	1229.54	.4143
195	379.45	384.67	844.99	1229.67	.4160
196	379.97	385.12	844.68	1229.80	.4178
197	380.30	385.56	844.36	1229.93	.4196
198	380.72	386.00	844.05	1230.06	.4214
199	381.15	386.44	843.74	1230.19	.4231
200	381.57	386.88	843.43	1230.31	.4249
201	381.99	387.32	843.12	1230.44	.4266
202	382.41	387.76	842.81	1230.57	.4283
203	382.82	388.19	842.50	1230.70	.4300
204	383.24	388.62	842.20	1230.82	.4318
205	383.65	389.05	841.89	1230.95	.4335
206	384.06	389.48	841.59	1231.07	.4352
207	384.47	389.91	841.29	1231.20	.4369
208	384.88	390.33	840.99	1231.32	.4386
209	385.28	390.75	840.69	1231.45	.4403
210	385.67	391.17	840.39	1231.57	.4421

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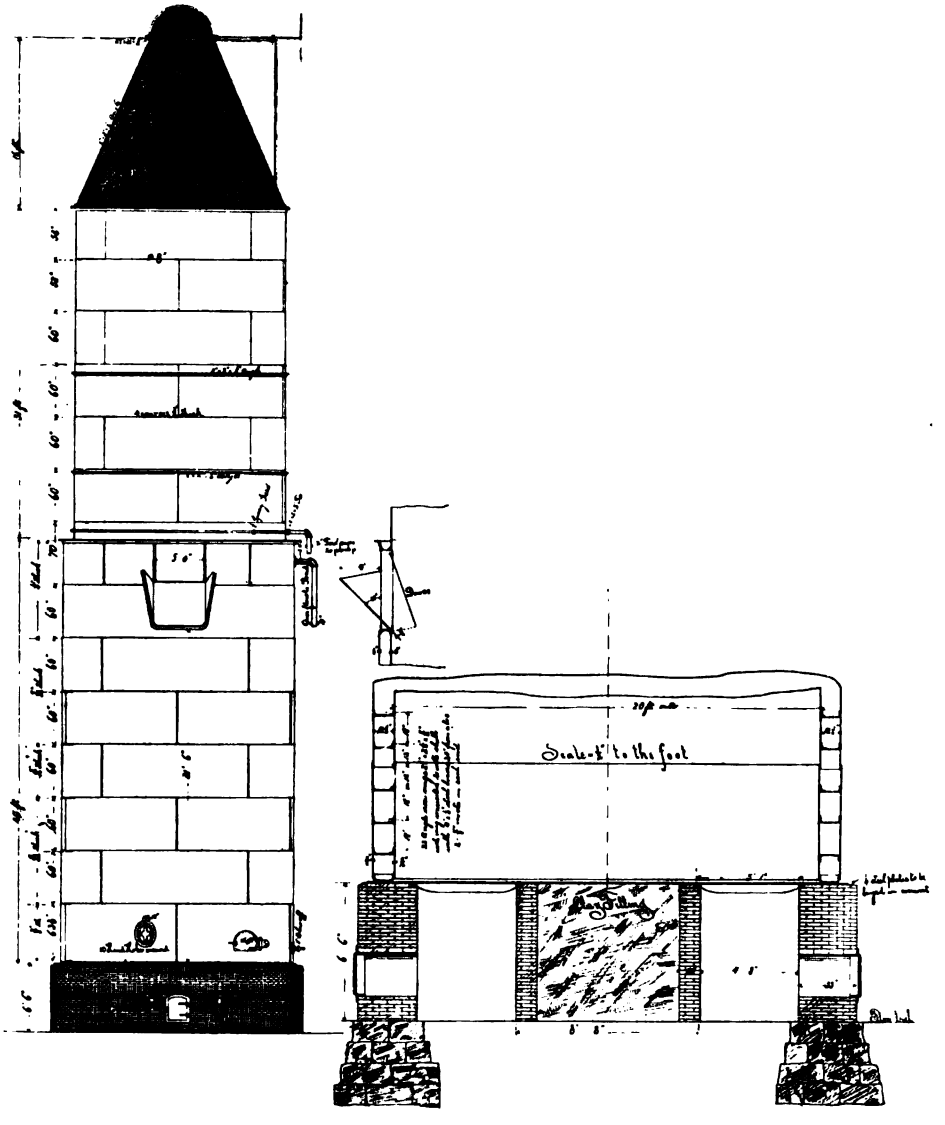

DRAWING.

Refuse Burner 100 Feet High, with Water Jacket 40 Feet High. Water Space 12⅝ Inches.

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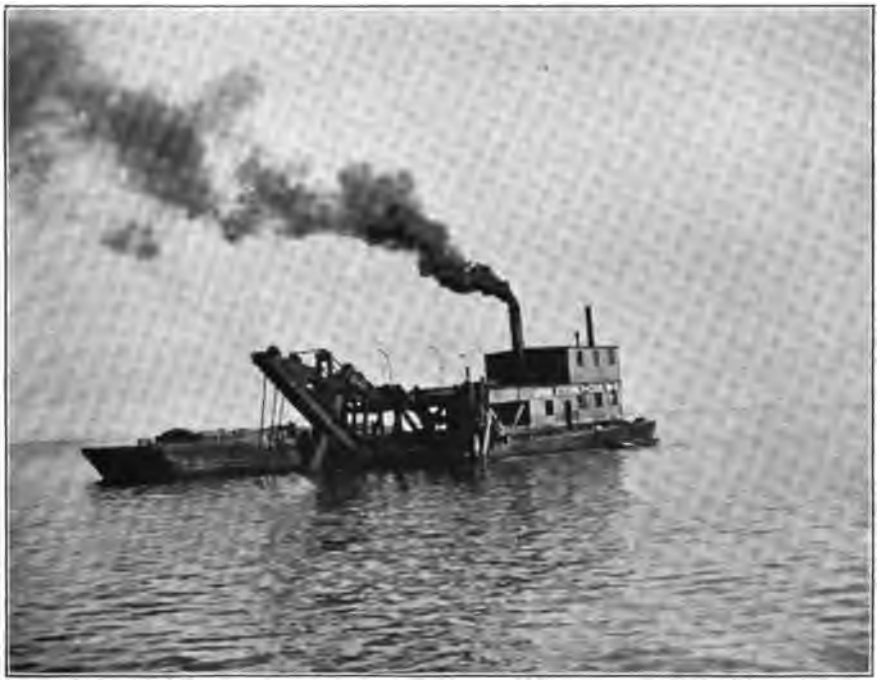
QUANTITIES OF HEAT CONTAINED IN ONE POUND OF WATER AT VARIOUS TEMPERATURES, RECKONED FROM ZERO, FAHRENHEIT.

(From Chas. T. Porter's Treatise on the Richards Steam Engine Indicator).

Temperature.	Heat contained above Zero.	Temperature.	Heat contained above Zero.	Temperature.	Heat contained above Zero.
Fahr., Deg.	B. T. U.	Fahr., Deg.	B. T. U.	Fahr., Deg.	B. T. U.
35	35.00	155	155.33	275	276.98
40	40.00	160	160.37	280	282.09
45	45.00	165	165.41	285	287.21
50	50.00	170	170.45	290	292.32
55	55.00	175	175.49	295	297.45
60	60.00	180	180.54	300	302.58
65	65.01	185	185.59	305	307.71
70	70.02	190	190.64	310	312.84
75	75.02	195	195.69	315	317.98
80	80.03	200	200.75	320	323.13
85	85.04	205	205.81	325	328.28
90	90.05	210	210.87	330	333.43
95	95.06	215	215.93	335	338.59
100	100.08	220	221.00	340	343.75
105	105.09	225	226.07	345	348.92
110	110.11	230	231.15	350	354.10
115	115.12	235	236.23	355	359.28
120	120.14	240	241.31	360	364.46
125	125.16	245	246.39	365	369.65
130	130.19	250	251.48	370	374.84
135	135.21	255	256.57	375	380.04
140	140.24	260	261.67	380	385.24
145	145.27	265	266.77	385	390.45
150	150.30	270	271.87	390	395.67



HEAVY ROCK DIGGING DREDGE.

Built for Carkin, Stickney & Cram. Boiler, Fire Box Marine, 7 Ft. x 12 Ft.

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WATER TOWER, MICHIGAN ASYLUM FOR THE INSANE, KALAMAZOO, MICH.
IRON WORK BUILT BY US.

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CIRCUMFERENCE OF CIRCLES.

Dia.	Circum.	Dia.	Circum.	Dia.	Circum.	Dia.	Circum.	Dia.	Circum.	Dia.	Circum.
1	3.1416	26	81.681	51	160.22	76	238.76	101	317.30	126	395.84
2	6.2832	27	84.823	52	163.36	77	241.90	102	320.44	127	398.98
3	9.4248	28	87.965	53	166.50	78	245.04	103	323.58	128	402.12
4	12.566	29	91.106	54	169.65	79	248.19	104	326.73	129	405.27
5	15.708	30	94.248	55	172.79	80	251.33	105	329.87	130	408.41
6	18.850	31	97.389	56	175.93	81	254.47	106	333.01	131	411.55
7	21.991	32	100.53	57	179.07	82	257.61	107	336.15	132	414.69
8	25.133	33	103.67	58	182.21	83	260.75	108	339.29	133	417.83
9	28.274	34	106.81	59	185.35	84	263.89	109	342.43	134	420.97
10	31.416	35	109.96	60	188.50	85	267.04	110	345.58	135	424.12
11	34.558	36	113.10	61	191.64	86	270.18	111	348.72	136	427.26
12	37.699	37	116.24	62	194.78	87	273.32	112	351.86	137	430.40
13	40.841	38	119.38	63	197.92	88	276.46	113	355.00	138	433.54
14	43.982	39	122.52	64	201.06	89	279.60	114	358.14	139	436.68
15	47.124	40	125.66	65	204.20	90	282.74	115	361.28	140	439.82
16	50.265	41	128.81	66	207.35	91	285.88	116	364.42	141	442.96
17	53.407	42	131.95	67	210.49	92	289.03	117	367.57	142	446.11
18	56.549	43	135.09	68	213.63	93	292.17	118	370.71	143	449.25
19	59.690	44	138.23	69	216.77	94	295.31	119	373.85	144	452.39
20	62.832	45	141.37	70	219.91	95	298.45	120	376.99	145	455.53
21	65.973	46	144.51	71	223.05	96	301.59	121	380.13	146	458.67
22	69.115	47	147.65	72	226.19	97	304.73	122	383.27	147	461.81
23	72.257	48	150.80	73	229.34	98	307.88	123	386.42	148	464.96
24	75.398	49	153.94	74	232.48	99	311.02	124	389.56	149	468.10
25	78.540	50	157.08	75	235.62	100	314.16	125	392.70	150	471.24

AREA OF CIRCLES.

Dia.	Area.	Dia.	Area.	Dia.	Area.	Dia.	Area.	Dia.	Area.	Dia.	Area.
⅛	0.0123	4½	15.904	16½	213 72	32	804.24	56	2463.0	80	5026.5
¼	0.0491	5	19.635	17	226.98	33	855.30	57	2551.7	81	5153.0
⅜	0.1104	5½	23.758	17½	240.52	34	907.92	58	2642.0	82	5281.0
½	0.1963	6	28.274	18	254.46	35	962.11	59	2733.9	83	5410.6
⅝	0.3067	6½	33.183	18½	268.80	36	1017.8	60	2827.4	84	5541.7
¾	0.4417	7	38.484	19	283.52	37	1075.2	61	2922.4	85	5674.5
⅞	0.6013	7½	44.178	19½	298.64	38	1134.1	62	3019.0	86	5908.8
1	0.7854	8	50.265	20	314.16	39	1194.5	63	3117.2	87	5944.6
1⅛	0.9940	8½	56.745	20½	330.06	40	1256.6	64	3216.9	88	6082.1
1¼	1.227	9	63.617	21	346.36	41	1320.2	65	3318.3	89	6221.1
1⅜	1.484	9½	70.882	21½	363.05	42	1385.4	66	3421.2	90	6361.7
1½	1.767	10	78.54	22	380.13	43	1452.2	67	3525.6	91	6503.8
1⅝	2.073	10½	86.59	22½	397.60	44	1520.5	68	3631.6	92	6647.6
1¾	2.405	11	95.03	23	415.47	45	1590.4	69	3739.2	93	6792.9
1⅞	2.761	11½	103.86	23½	433.73	46	1661.9	70	3848.4	94	6939.7
2	3.141	12	113.09	24	452.39	47	1734.9	71	3959.2	95	7088.2
2¼	3.976	12½	122.71	24½	471.43	48	1809.5	72	4071.5	96	7238.2
2½	4.908	13	132.73	25	490.87	49	1885.7	73	4185.3	97	7389.8
2¾	5.939	13½	143.13	26	530.93	50	1963.5	74	4300.8	98	7542.9
3	7.068	14	153.93	27	572.55	51	2042.8	75	4417.8	99	7697.7
3¼	8.295	14½	165.13	28	615.75	52	2123.7	76	4536.4	100	7854.0
3½	9.621	15	176.71	29	660.52	53	2206.1	77	4656.0	101	8011.8
3¾	11.044	15½	188.69	30	706.86	54	2290.2	78	4778.3	102	8171.3
4	12.566	16	201.06	31	754.76	55	2375.8	79	4901.6	103	8332.3

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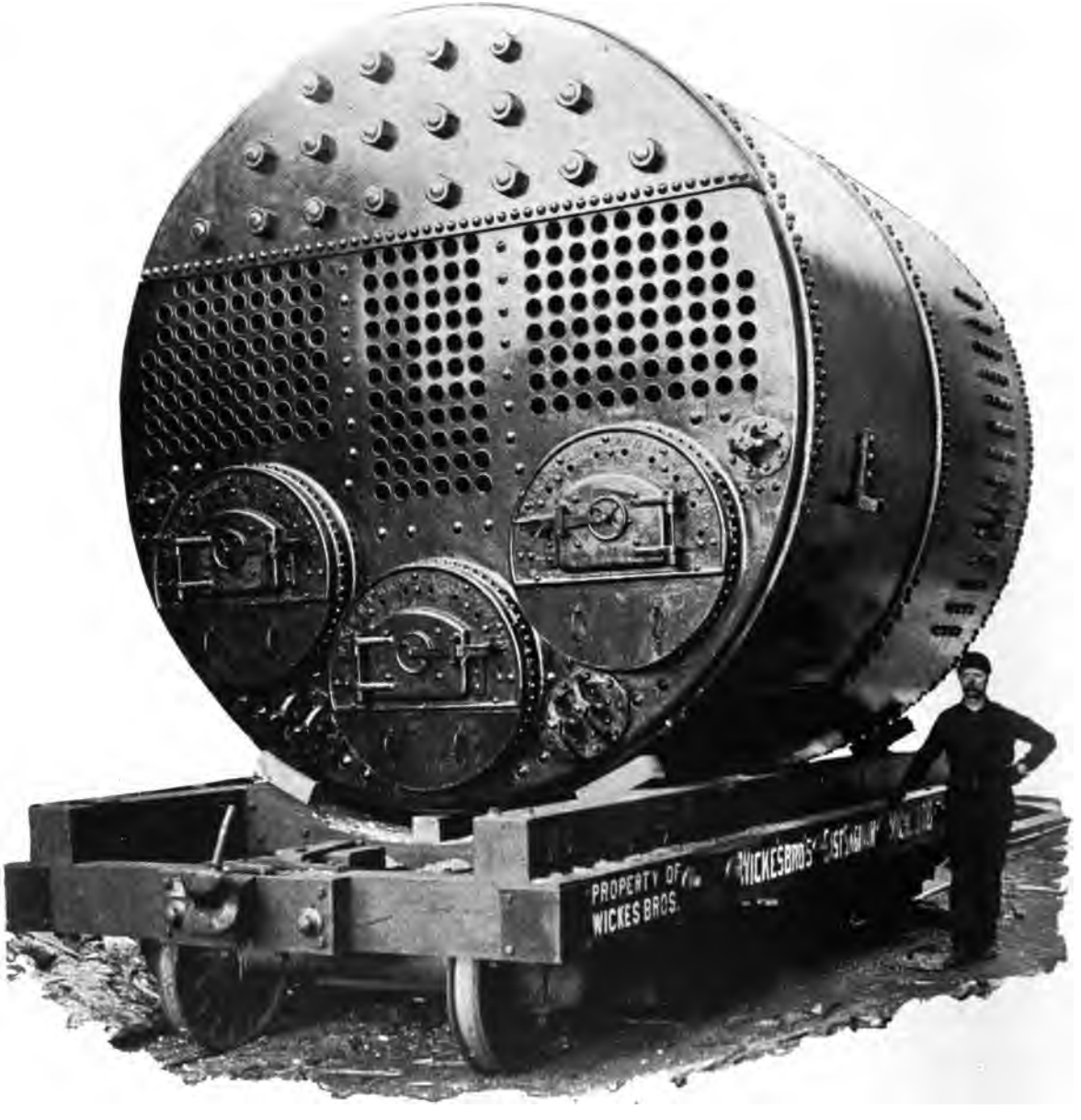

THREE-FURNACE SCOTCH BOILER LOADED ON ONE OF OUR SPECIAL CARS READY FOR SHIPMENT.
WEIGHT 46 TONS.

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TO REDUCE ACTUAL EVAPORATION TO THE STANDARD AT AND FROM 212° FAHR.

The quantity of heat required for evaporating one pound of water under atmospheric pressure at and from 212° Fahr. is 965.66 units.

W = actual evaporation in pounds of water per unit of time.

w = standard evaporation at and from 212° Fahr.

H = units of heat per pound of the steam actually evaporated and to be found in the steam table.

h = units of heat per pound of the feed-water to be found in the water table.

$$w = \frac{W.\,(H. - h.)}{965.66}$$

The actual evaporation multiplied by the tabular number is the standard evaporation.

STEAM PRESSURE IN BOILER ABOVE ATMOSPHERE.

Temp. Feed Water.	30	40	50	60	70	80	90	100	110	120	130	140	150
32°	1.207	1.211	1.214	1.217	1.220	1.223	1.225	1.227	1.229	1.231	1.233	1.234	1.236
40°	1.199	1.203	1.206	1.209	1.212	1.214	1.217	1.219	1.221	1.223	1.224	1.226	1.228
50°	1.188	1.192	1.196	1.199	1.201	1.204	1.206	1 208	1.210	1.212	1.214	1.216	1.217
60°	1.178	1.182	1.185	1.188	1.191	1.194	1.196	1.198	1.200	1.202	1.204	1.205	1.207
70°	1.167	1.171	1.175	1.178	1.181	1.183	1.185	1.188	1.190	1.191	1.193	1.195	1.196
80°	1.157	1.161	1.165	1.168	1.170	1.173	1.175	1.177	1.179	1.181	1.183	1.185	1.186
90°	1.147	1.151	1.154	1.157	1.160	1.162	1.165	1.167	1.169	1.171	1.172	1.174	1.176
100°	1.136	1.140	1.144	1.147	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.165
110°	1.126	1.130	1.133	1.136	1.139	1.142	1.144	1.146	1.148	1.150	1.152	1.153	1.155
120°	1.116	1.120	1.123	1.126	1.129	1.131	1.134	1.136	1.138	1.140	1.141	1.143	1.145
130°	1.105	1.109	1.113	1.116	1.118	1.121	1.123	1.125	1.127	1.129	1.131	1.133	1.134
140°	1.095	1.099	1.102	1.105	1.108	1.110	1.113	1.115	1.117	1.119	1.120	1.122	1.124
150°	1.085	1.088	1.092	1.095	1.098	1.100	1.102	1.104	1.106	1.108	1.110	1.112	1.113
160°	1.074	1.078	1.081	1.084	1.087	1.090	1.092	1.094	1.096	1.098	1.100	1.101	1.103
170°	1.064	1.067	1.071	1.074	1.077	1.079	1.081	1.084	1.086	1.087	1.089	1.091	1.092
180°	1.053	1.057	1.060	1.064	1.066	1.069	1.071	1.073	1.075	1.077	1.079	1.080	1.082
190°	1.049	1.047	1.050	1.053	1.056	1.058	1.061	1.063	1.065	1.067	1.068	1.070	1.072
200°	1.032	1.036	1.040	1.043	1.045	1.048	1.050	1.052	1.054	1.056	1.058	1.059	1.061
210°	1.022	1.026	1.030	1.032	1.035	1.037	1.040	1.042	1.014	1.046	1.047	1.049	1.051

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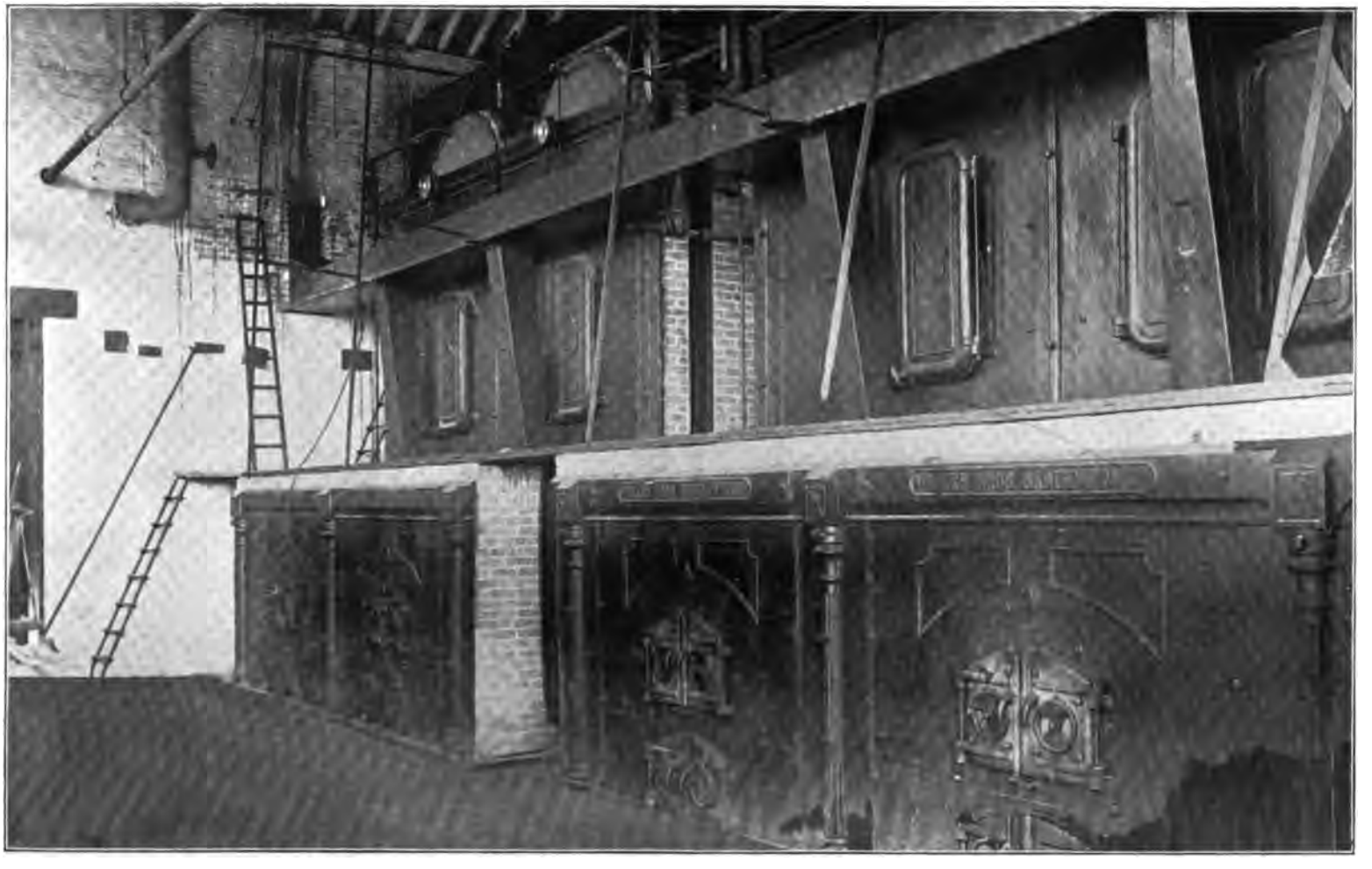

INTERIOR BOILER PLANT OWNED BY C. K. EDDY & SONS.

SHOWING APPLICATION TO WOOD BOILERS OF SHAVING AND SAWDUST BURNING FURNACES, EQUIPPED WITH CONVEYING AND DISTRIBUTING MACHINERY.

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HEATING SURFACE.

WHEN considering the choice of a boiler, one of the vital points to be considered is the kind and quantity of heating surface offered.

As the efficiency of the boiler depends, first: upon the thoroughness of the combustion; and second, upon the absorption of the heat of combustion by the water, it will be seen at once that the kind of heating surface, and the method of conducting the heat along and through that heating surface in a boiler is of the greatest importance, for the more completely the surface is surrounded by the heat the greater becomes the evaporation from the given unit of fuel used, and therefore, the higher the efficiency of the boiler.

In this consideration, a factor of nearly as great importance as the direction and method of conducting the heat currents, is the facility offered for quick access and readiness of cleaning this surface. We invite a thorough inspection of the heating surface in the **Wood Boiler** from both of the above considerations, and wish to invite especial attention to the number of passages that the currents of heat must take before entering the stack, and the manner in which the currents of heat surround every foot of heating surface while traveling the total length of it. This longitudinal method of conducting the products of combustion insures a thorough absorption by the

What Kind of Heating Surface.

ONE OF THREE SCOTCH BOILERS, WEIGHING 50 TONS EACH, READY TO HOIST INTO STEAMSHIP.

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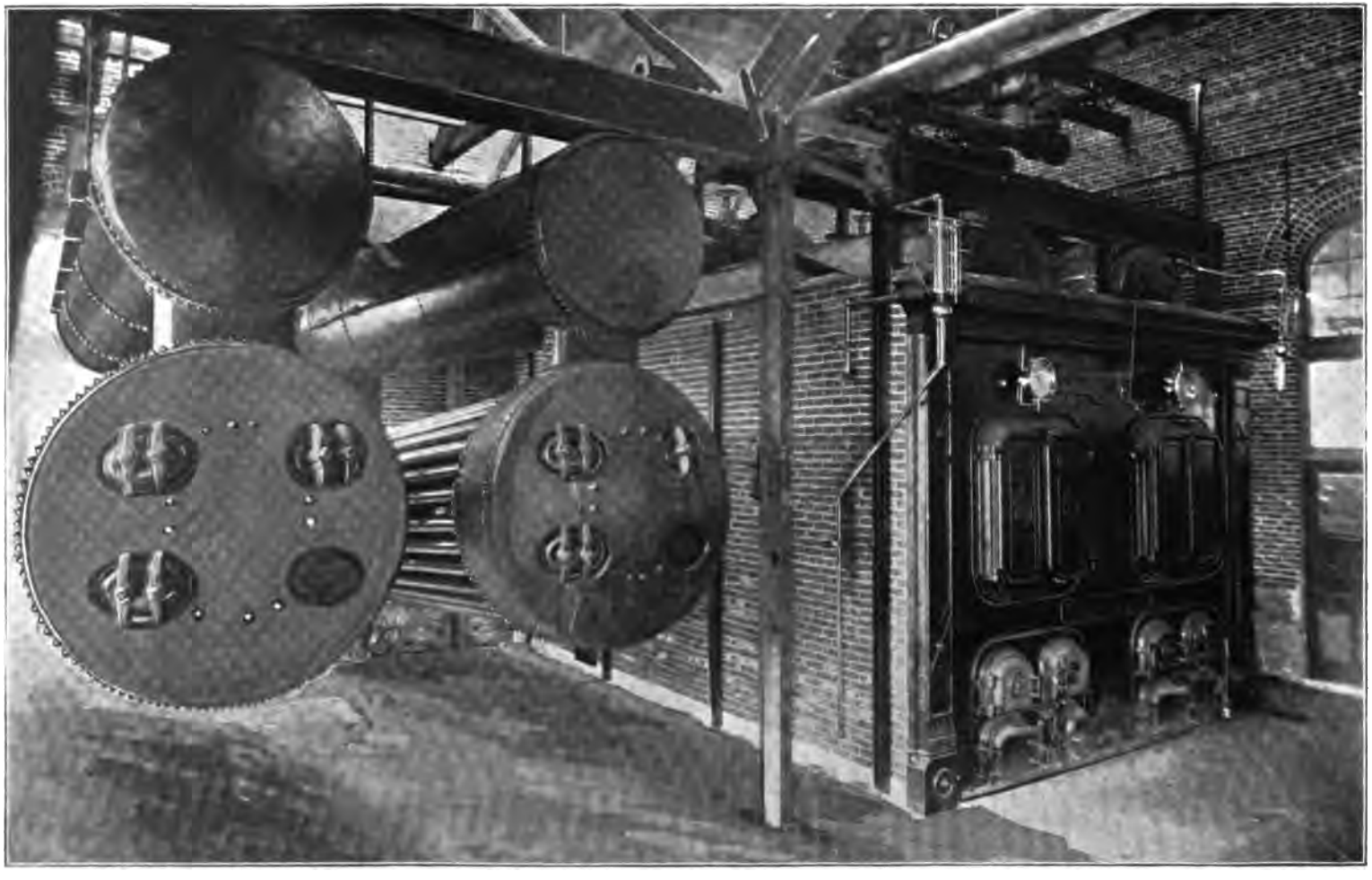

INTERIOR, SHOWING WOOD WATER TUBE BOILERS AS LOCATED AND BEING ERECTED IN DAYTON CITY WATER WORKS, DAYTON, OHIO.

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water of the heat generated, and therefore, the absence of those high flue temperatures so noticeable in some forms.

Get Enough Heating Surface.

Next in importance to the efficiency of the heating surface is the quantity offered for each Horse Power, and the value of this item is made notable by the fact that engineers, in drawing up specifications, are stipulating the total square feet of heating surface, making no mention of the Horse Power desired.

The following table will be found useful in calculating the amount of heating surface offered by various builders:

BOILER TUBES.

External Diameter.	Draught Area in sq. inches.	Draught Area in sq. feet.	Heating Surface in feet per foot of tube in length.	No. of Tubes in one sq. foot of draught area.
⅝ inch.	.....	.....	.1636	.....
¾ "	.....	.....	.1963	.....
1 "	.575	.0040	.2618	250.0
1¼ "	.968	.0067	.3272	149.3
1½ "	1.389	.0096	.3927	103.7
1¾ "	1.911	.0133	.4581	75.2
2 "	2.573	.0179	.5236	55.9
2¼ "	3.333	.0231	.5891	43.3
2½ "	4.083	.0284	.6545	35.2
2¾ "	5.027	.0349	.7200	28.7
3 "	6.070	.0422	.7854	23.7
3¼ "	7.116	.0494	.8508	20.2
3½ "	8.347	.0580	.9163	17.2
3¾ "	9.673	.0672	.9818	14.9
4 "	10.93	.0759	1.0472	13.2
4½ "	14.05	.0996	1.1781	10.2
5 "	17.35	.1205	1.3090	8.3
6 "	25.25	.1753	1.5708	5.7
7 "	34.94	.2426	1.8326	4.1
8 "	46.20	.3208	2.0944	3.1
9 "	58.63	.4072	2.3562	2.5
10 "	72.23	.5016	2.6180	2.0

Our Rating.

The **Wood Boiler** is rated on the basis of 11 square feet of heating surface to the Horse Power, and this amount of heating surface is always given unless a different amount is called for by specifications.

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WOOD WATER TUBE BOILERS AT THE WORLD'S FAIR, 1893. BURNING TICKETS RECEIVED AT THE GATES.

(From Frank Leslie's Illustrated Weekly, August 3, 1893).

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HORSE-POWER.

CORRECTLY speaking, there is no such thing as horse-power when applied to a boiler, but realizing the convenience in a commercial sense, such a limit of work was recommended by the American Society of Mechanical Engineers, in November, 1881, and has since come into accepted use. As recommended, the Horse-power is the evaporation of 30 pounds of water per hour from a feed water temperature of 100° F. into steam at 70 pounds gauge pressure, which shall be considered to be equal to 34½ units of evaporation—that is, to 34½ pounds of water evaporated from a feed water temperature of 212° F. into steam at the same temperature.

Horse Power.

The Horse-power of the **Wood Boiler** is rated on this standard, and has so liberal an amount of water heating surface that it can, while exhibiting good economy of fuel, be run at 50 per cent. and more above this power, thereby carrying out the true intent and spirit of the committee establishing this standard Horse-power, as they have cited in their full report. A recently quite popular method of measuring the commmercial efficiency of the boiler and furnace combined, is to determine the cost of evaporating from and at 212° F. 1,000 lbs. of water.

Our Horse Power.

In the following table by multiplying the decimal opposite the observed evaporation from and at 212° F. per pound of coal, by the cost of coal in dollars and cents, the result will be the cost of evaporating 1,000 pounds of water from and at 212° F. in coal consumption.

10	pounds	of	water	to	1	coal	constant	.....	.05
9½	"	"	"	"	"	"	"	.....	.0526
9	"	"	"	"	"	"	"	.....	.0556
8½	"	"	"	"	"	"	"	.....	.0588
8	"	"	"	"	"	"	"	.....	.0625
7½	"	"	"	"	"	"	"	.....	.0667
7	"	"	"	"	"	"	"	.....	.0714
6½	"	"	"	"	"	"	"	.....	.0769
6	"	"	"	"	"	"	"	.....	.0833

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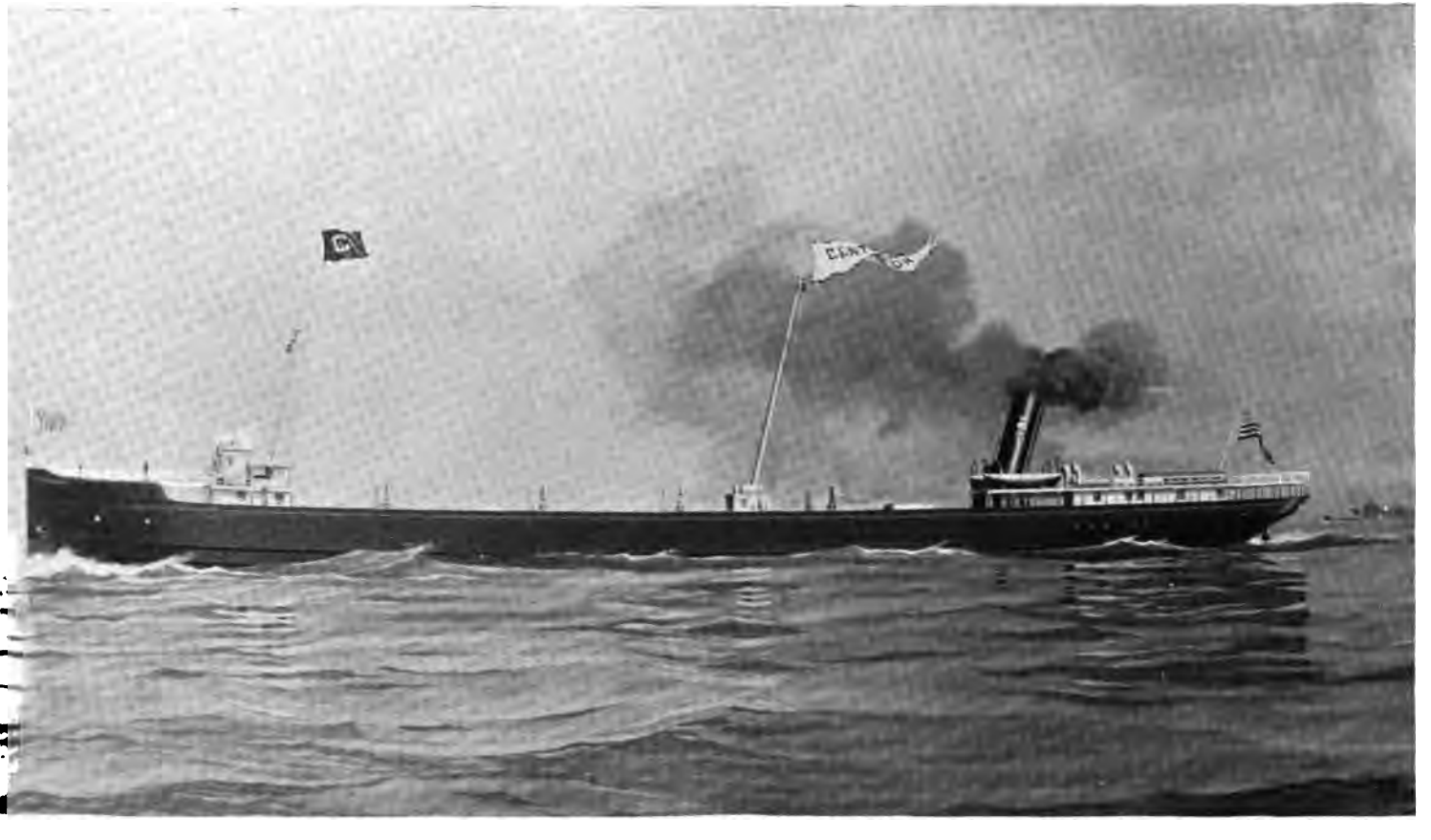

STEAMSHIP "CENTURION."

HAS A RECORD OF CARRYING 147,812 BUSHELS OF CORN FROM CHICAGO TO ERIE, AND HOLDS THE RECORD FOR THE QUICKEST TRIP BETWEEN BUFFALO AND DULUTH. IS FITTED OUT WITH THREE SCOTCH MARINE BOILERS, 12 1-2 FT X 12 FT., ALLOWED 170 LBS. PRESSURE.

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CODE OF RULES FOR BOILER TESTS.

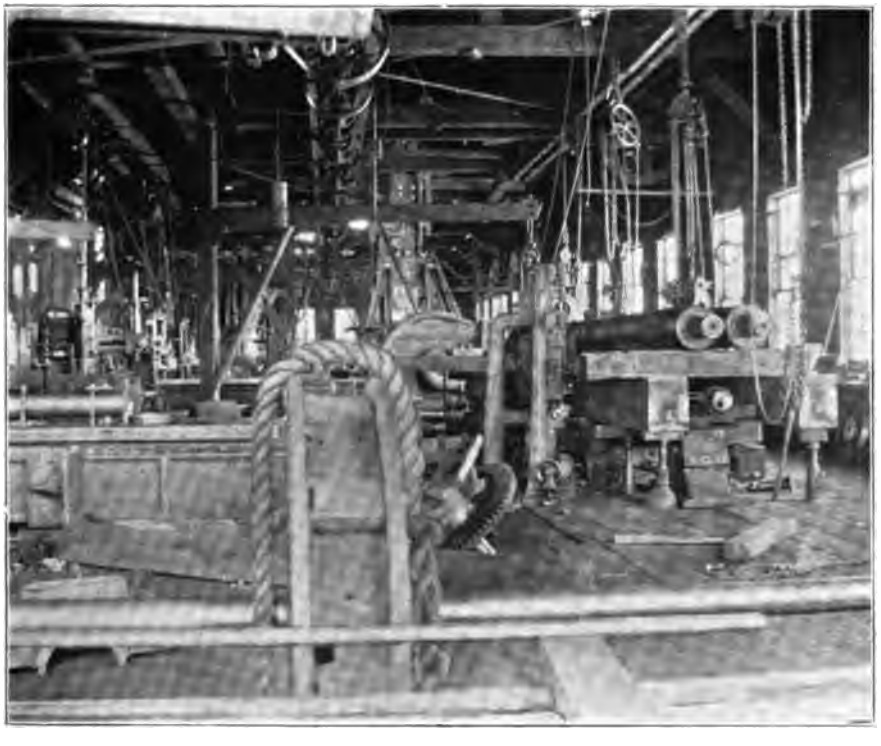
(Recommended by the American Society of Mechanical Engineers; November, 1884).

STARTING AND STOPPING A TEST.

A TEST should last at least ten hours of continuous running, and twenty-four hours whenever practicable. The conditions of the boiler and furnace in all respects should be, as nearly as possible, the same at the end as at the beginning of the test. The steam pressure should be the same, the water level the same, the fire upon the grates should be the same, in quantity and condition, and the walls, flues, etc., should be of the same temperature. To secure as near an approximation to exact uniformity as possible in conditions of the fire and in the temperatures of the walls and flues, the following method of starting and stopping a test should be adopted:

STANDARD METHOD.—Steam being raised to the working pressure, remove rapidly all the fire from the grate, close the damper, clean the ash pit, and as quickly as possible start a new fire with weighed wood and coal, noting the tone of starting test and the height of the water level while the water is in a quiescent state just before lighting the fire.

At the end of the test, remove the whole fire, clean the grates and ash pit and note the water level when the water is in a quiescent state; record the time



INTERIOR MACHINE SHOP, NORTH WING.

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LAUNCHING STEAMSHIP "UGANDA."
HAS TWO 11 1-2 FT. X 12 FT. BOILERS, CARRYING 160 LBS. PRESSURE.

of hauling the fire as the end of the test. The water level should be as nearly as possible the same as at the beginning of the test. If it is not the same, a correction should be made by computation, and not by operating pump after test is completed. It will generally be necessary to regulate the discharge of steam from the boiler tested by means of the stop valve for a time while fires are being hauled at the beginning and at the end of the test, in order to keep the steam pressure in the boiler at those times up to the average during the test.

ALTERNATE METHOD.—Instead of the Standard Method above described, the following may be employed where local conditions render it necessary:

At the regular time for slicing and cleaning fires, have them burned rather low, as is usual before cleaning, and then thoroughly cleaned; note the amount of coal left on the grate as nearly as it can be estimated; note the pressure of the steam and the height of the water level—which should be at the medium height to be carried throughout the test—at the same time; and note this time as the time of starting the test. Fresh coal, which has been weighed, should now be fired. The ash pits should be thoroughly cleaned at once after starting. Before the end of the test the fires should be burned low, just as before the start, and the fires cleaned in such a manner as to leave the same amount of fire, and in the same condition, on the grates as at the start. The water level and steam pressure should be brought to the same point as at the start, and the time of the ending of the test should be noted just before fresh coal is fired.

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DURING THE TEST.

KEEP THE CONDITIONS UNIFORM.—The boiler should be run continuously without stopping for meal-times or for rise or fall of pressure of steam due to change of demand for steam. The draught being adjusted to the rate of evaporation or combustion desired before the test is begun, it should be retained constant during the test by means of the damper.

If the boiler is not connected to the same steam pipe with other boilers, an extra outlet for steam with valve in same, should be provided, so that in case the pressure should rise to that at which the safety valve is set, it may be reduced to the desired point by opening the extra outlet, without checking the fires.

NEW ENGLAND FURNITURE COMPANY, GRAND RAPIDS, MICH.
SUPPLIED WITH ONE 150 H. P. WOOD WATER TUBE BOILER.

If the boiler is connected to a main steam pipe with other boilers, the safety valve on the boiler being tested should be set a few pounds higher than those of the other boilers, so that in case of a rise in the pressure the other boilers may blow off, and the pressure be reduced by closing their dampers, allowing the damper of the boiler being tested to remain open, and firing as usual.

All the conditions should be kept as nearly uniform as possible, such as force of draught, pressure of steam, and height of water. The time of cleaning the fires will depend upon the character of the fuel, the rapidity of combustion, and the kind of grates. When very good coal is used, and the combustion not

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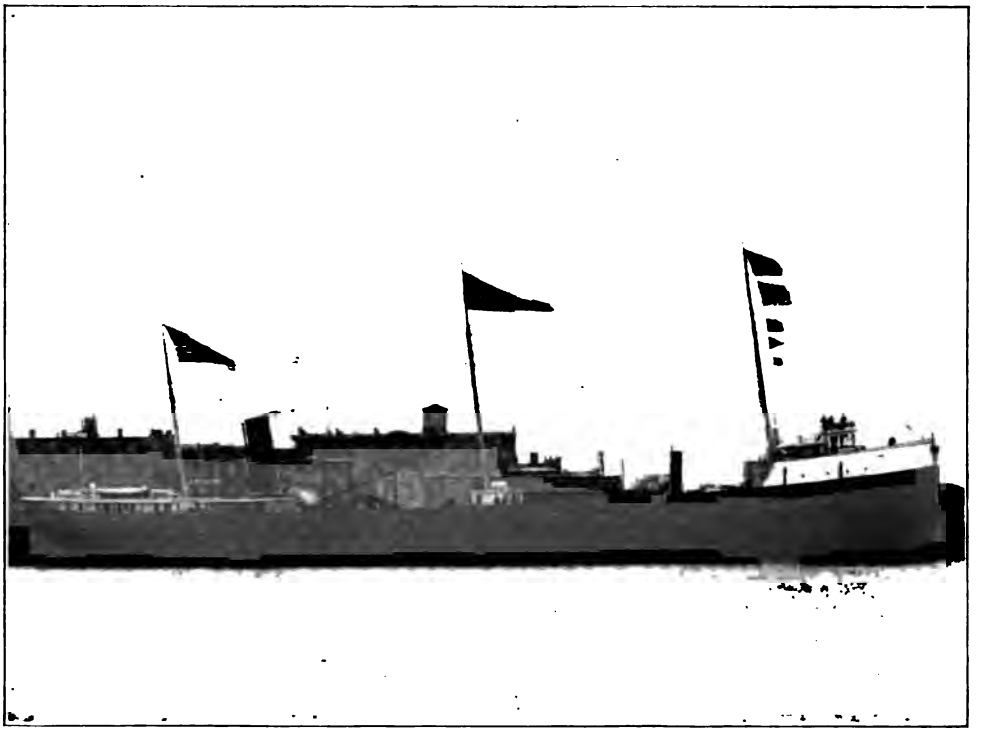
too rapid, a ten-hour test may be run without any cleaning of the grates other than just before the beginning and just before the end of the test. But in case the grates have to be cleaned during the test, the intervals between one cleaning and another should be uniform.

KEEPING THE RECORDS.—The coal should be weighed and delivered to the firemen in equal portions, each sufficient for about one hours run, and fresh portion should not be delivered until the previous one has all been fired. The time required to consume each portion should be noted, the time being recorded at the instant of firing the first of each new portion. It is desirable that at the same time the amount of water fed into the boiler should be accurately noted and recorded, including the height of the water in the boiler, and the average pressure of steam and temperature of feed during the time. By thus recording the amount of water evaporated by successive portions of coal, the record of the test may be divided into several divisions, if desired, at the end of the test, to discover the degree of uniformity of combustion, evaporation, and economy at different stages of the test.

PRIMING TESTS.—In all tests in which accuracy of results is important, calorimeter tests should be made of the percentage of moisture in the steam, or of the degree of superheating. At least ten such tests should be made during the trial of the boiler, or so many as to reduce the probable average error to less



STEAMER "W. F. SAUBER."
FITTED WITH SCOTCH MARINE BOILER 13FT. X 13 FT., CARRYING 160 LBS. PRESSURE.

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BEARINGER BUILDING, SAGINAW, MICH.
USING THE WOOD WATER TUBE BOILERS.

than one per cent., and the final records of the boiler test corrected according to the average results of the calorimeter tests.

On account of the difficulty in securing accuracy in these tests, the greatest care should be taken in the measurements of weights and temperatures. The thermometers should be accurate to within a tenth of a degree, and the scales on which the water is weighed to within one-hundredth of a pound.

ANALYSES OF GASES, MEASUREMENT OF AIR SUPPLY, ETC.

In tests for purposes of scientific research, in which the determination of all the variables entering into the test is desired, certain observations should be made which are in general not necessary in tests for commercial purposes. These are the measurement of the air supply, the determination of its contained moisture, the measurement and analysis of the flue gases, the determination of the amount of heat lost by radiation, of the amount of infiltration of air through the setting, the direct determination by calorimeter experiments, of the absolute

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heating value of the fuel, and (by condensation of all the steam made by the boiler) of the total heat imparted to the water.

The analysis of the flue gases is an especially valuable method of determining the relative value of different methods of firing, or of different kinds of furnaces. In making these analyses great care should be taken to procure average samples—since the composition is apt to vary at different points of the flue—and the analyses should be entrusted only to a thoroughly competent chemist, who is provided with complete and accurate apparatus.

As the determinations of the other variables mentioned above are not likely to be undertaken except by engineers of high scientific attainments, and as apparatus for making them is likely to be improved in the course of scientific research, it is not deemed advisable to include in this code any specific directions for making them.

RECORD OF THE TEST.

A "log" of the test should be kept on properly prepared blanks, containing headings as follows:

	Pressures.			Temperatures.					Fuel.		Feed Water.	
Time.	Barometer.	Steam Gauge.	Draught Gauge.	External Air.	Boiler Room.	Flue.	Feed Water.	Steam.	Time.	Lbs.	Time.	Lbs. or Cu. Ft.

REPORTING THE TRIAL.

The final results should be recorded upon a properly prepared blank, and should include as many of the following items as are adapted for the specific object for which the trial is made. The items marked with an * may be omitted for ordinary trials, but are desirable for comparison with similar data from other sources.

Results of the trial of a.....

Boiler at.....

To determine.....

1. Date of trial, ...	. . . . .	
2. Duration of trial, ...	Hours,. .	
DIMENSIONS AND PROPORTIONS.		
(Leave space for complete description).		
3. Grate surface, . . . wide, . . . long, . . . Area, ...	Sq. ft. . .	
4. Water heating surface, ...	Sq. ft. . .	
5. Superheating surface, ...	Sq. ft. . .	
6. Ratio of water heating surface to grate surface, ...	. . . . .	
AVERAGE PRESSURES.		
7. Steam pressure in boiler, by gauge,.	Lbs. . . .	
* 8. Absolute steam pressure, ...	Lbs. . . .	
* 9. Atmospheric pressure, per barometer, ...	Inches .	
10. Force of draught in inches of water, ...	Inches .	

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	AVERAGE TEMPERATURES.		
*11.	Of external air,	Degrees.	
*12.	Of fire-room,	Degrees.	
*13.	Of steam,	Degrees.	
14.	Of escaping gases,	Degrees.	
15.	Of feed water,	Degrees.	
	FUEL.		
16.	Total amount of coal consumed,	Lbs.	
17.	Moisture in coal,	Per cent.	
18.	Dry coal consumed,	Lbs.	
19.	Total refuse, dry, . . . pounds	Per cent.	
20.	Total combustible (dry weight of coal, item 18, less refuse, item 19)	Lbs.	
*21.	Dry coal consumed per hour,	Lbs.	
*22.	Combustible consumed per hour,	Lbs.	
	RESULTS OF CALORIMETRIC TESTS.		
23.	Quality of steam, dry steam being taken as unity	. . . . .	
24.	Percentage of moisture in steam,	Per cent.	
25.	No. of degrees superheated,	Degrees.	
	WATER.		
26.	Total weight of water pumped into boiler and apparently evaporated	Lbs.	
27.	Water actually evaporated, corrected for quality of steam,	Lbs.	
28.	Equivalent water evaporated from and at 212° F.	Lbs.	
*29.	Equivalent total heat derived from fuel in British thermal units	B. T. U.	
30.	Equivalent water evaporated into dry steam from and at 212° F.	Lbs.	
	ECONOMIC EVAPORATION.		
31.	Water actually evaporated per pound of dry coal, from actual pressure and temperature,	Lbs.	
32.	Equivalant water evaporated per pound of dry coal from and at 212° F.	Lbs.	
33.	Equivalent water evaporated per pound of combustible from and at 212° F.	Lbs.	
	COMMERCIAL EVAPORATION.		
34.	Equivalent water evaporated per pound of dry coal with one-sixth refuse, at 70 pounds gauge pressure, from temperature of 100° F. =item 33 multiplied by 0.7249	Lbs.	
	RATE OF COMBUSTION.		
35.	Dry coal actually burned per square foot of grate surface per hour,	Lbs.	
*36.	Consumption of dry coal — Per sq. ft. of grate surface,	Lbs.	
*37.	per hour. Coal assumed — Per sq. ft. of water-heating surface.	Lbs.	
*38.	with one-sixth refuse, — Per sq. ft. of least area for draught,	Lbs.	
	RATE OF EVAPORATION.		
39.	Water evaporated from and at 212° F. per sq. ft. of heating surface per hour,	Lbs.	
*40.	Water evaporated per hour — Per sq. ft. of grate surface,	Lbs.	
*41.	from temperature of 100° — Per sq. ft. of water-heating surface,	Lbs.	
*42.	F. into steam of 70 pounds gauge pressure, — Per sq. ft. of least area for draught,	Lbs.	
	COMMERCIAL HORSE-POWER.		
43.	On basis of 30 pounds of water per hour evaporated from temperature of 100° F. into steam of 70 pounds gauge pressure (=34½ pounds from and at 212° F.)	H. P.	
44.	Horse-power, builder's rating, at . . . square feet per horse-power,	H. P.	
45.	Per cent. developed above, or below, rating,	Per cent.	

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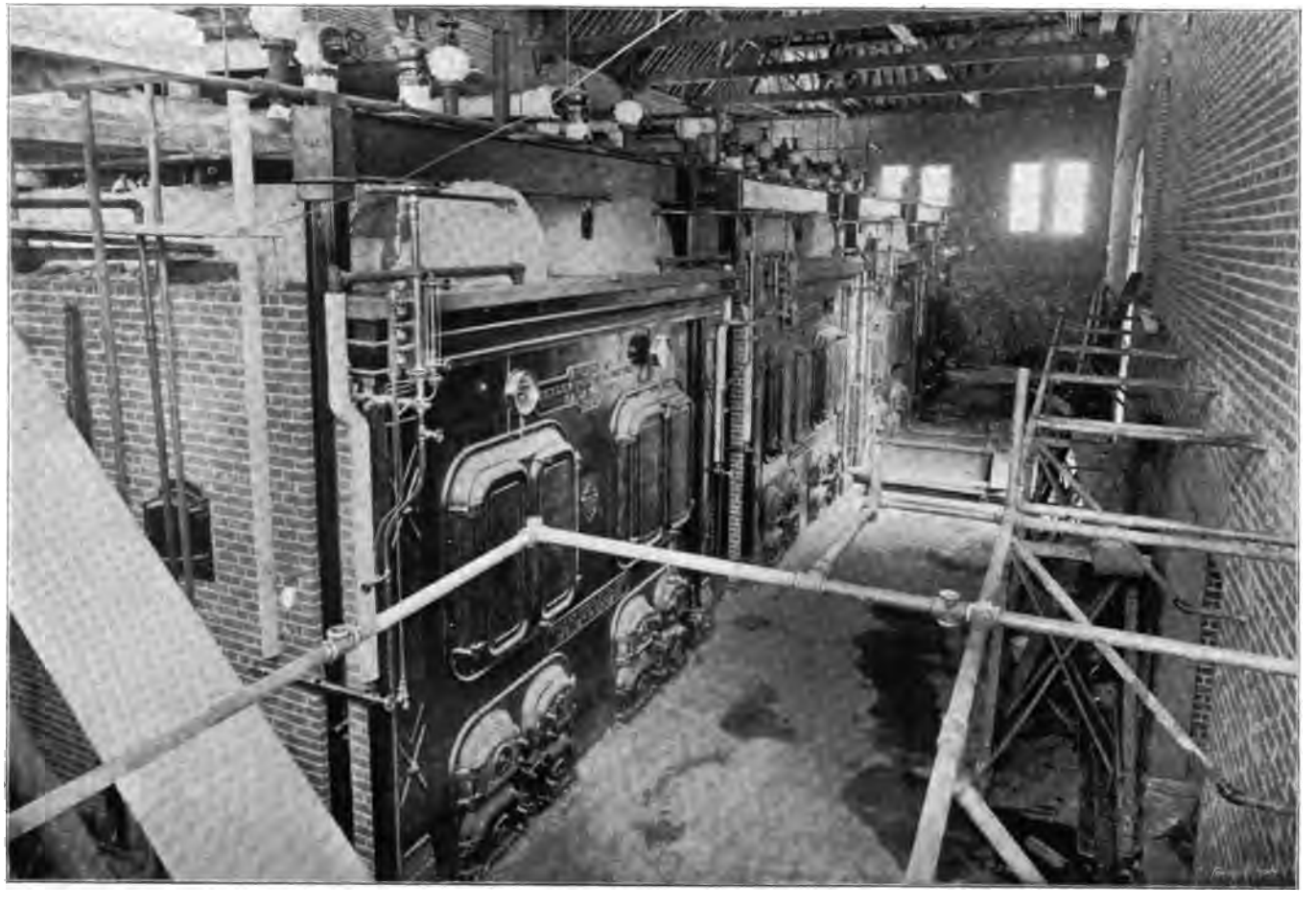

EIGHT, 150 H. P. EACH, WOOD WATER TUBE BOILERS, LOCATED IN POWER HOUSE OF MICHIGAN ASYLUM FOR THE INSANE, KALAMAZOO, MICH.

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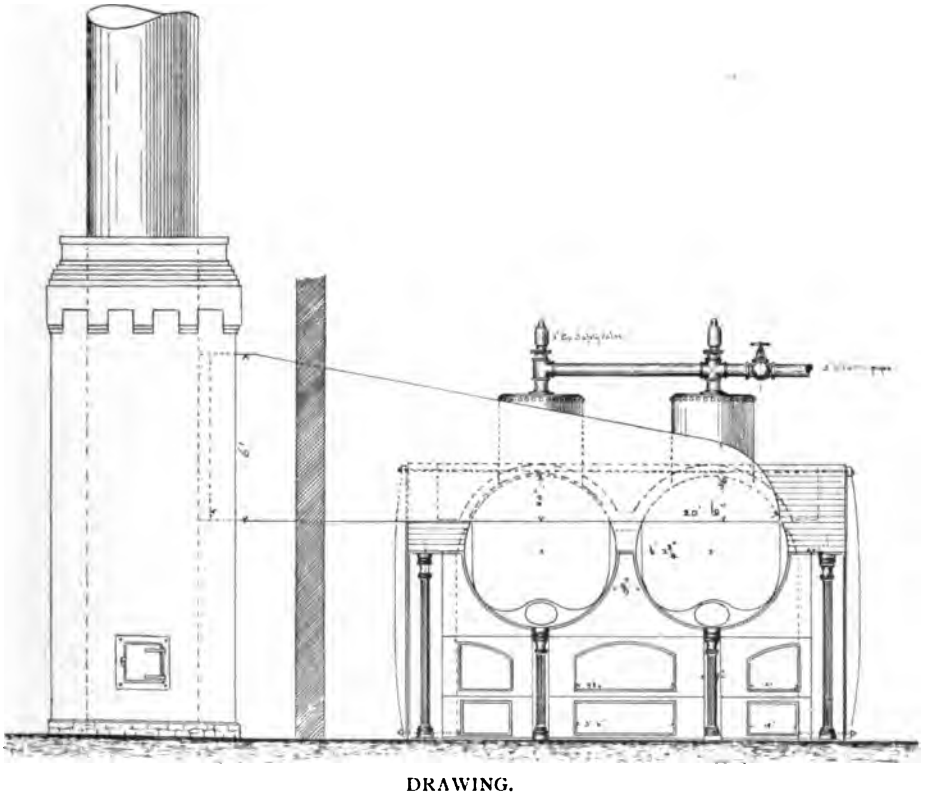
THE MANAGEMENT OF STEAM BOILERS.

As Recommended by the Steam Boiler Insurance Companies.

IT is of fully as great importance to manage a boiler properly as to have it properly designed and constructed. Poor management will soon render the best boiler useless. From the time a boiler is set at work it is subject to destroying forces, which must be counteracted so far as is possible.

The fireman is the person under whose immediate care the boiler properly comes, and his duties, from not being generally understood, are apt to be undervalued, although they call for more knowledge than is generally supposed. To attend to his duty properly, he should know his business thoroughly, be prompt, reliable, careful, and last, but not least, sober. There is a general adaptability for the situation about some men, but others might work a lifetime at the business and never learn it thoroughly. A certain handiness in the use of tools of various kinds is almost a necessity, although it is not necessary for him to have learned any trade, and he should have some pride in his work. It is not too much to say that a really good fireman is an almost invaluable man, and that he saves his wages to his employer more than twice over by the care and economy he exercises.

Kind of Man.



DRAWING.

Showing Battery of Tubular Boilers equipped with Side Breeching leading to Brick Stub.

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One thing is very important for owners to remember, which is this: *The fireman should have nothing to do except to attend to his boiler—Verbum sat.*

Before Starting. Before starting a fire under a boiler the fireman should see that there is plenty of water in the boiler, by trying the gauge-cocks; if there is not, he must at once fill the boiler to the proper level. Then he should see that the blow-cock is shut, that the hand-hole plates do not leak, or if they do he must make them tight, and he should look to see if there are leaks in the seams or at the tube-ends. He should then see that the furnaces and flues are clear as well as the front connection, that the damper is open, that the ashpit is clear, and all ashes removed from in front of the boilers, and that the grate-bars are in good order, for if not he must remove the badly-warped or broken ones and substitute others. He should then raise the safety-valve to allow air to escape while steam is forming, and should also open the upper gauge-cock to give notice when the steam begins to form, and he should also ease the stop-valve, if there is one, to prevent its setting fast. If the dampers and doors do not move freely, he should cause them to do so.

Starting Up. Everything being now ready, he should cover the grate-bars with coal for about two-thirds of their length from the bridge, and should pile a little wood, cob-house fashion, on the open bars, and put a few lighted shavings, or oily waste, in the mouth of the furnace, partially close the furnace

GRAND RAPIDS CHAIR COMPANY, GRAND RAPIDS, MICH.
EQUIPPED WITH TWO 200 H. P. EACH WOOD WATER TUBE BOILERS.

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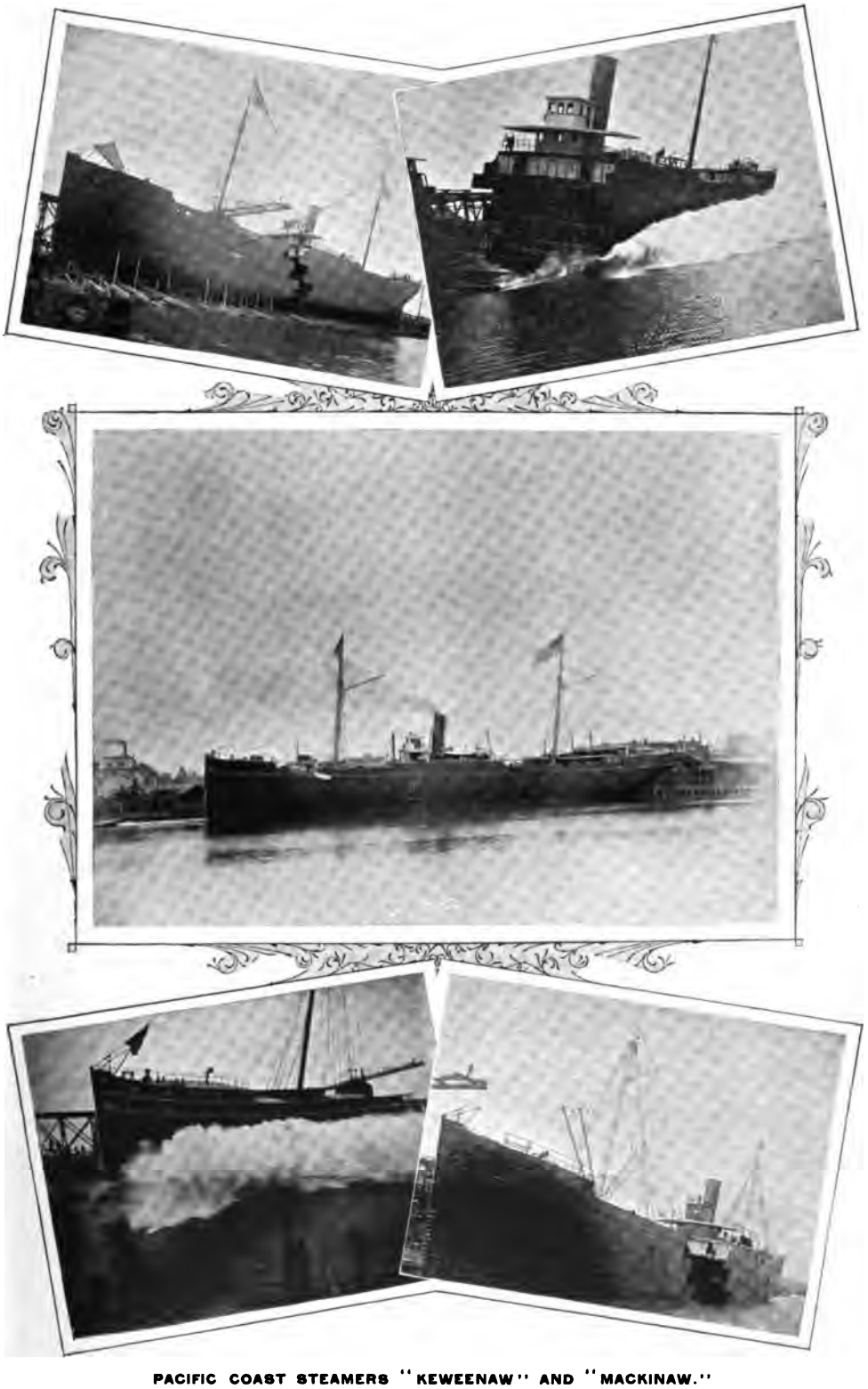

PACIFIC COAST STEAMERS "KEWEENAW" AND "MACKINAW."
BUILT BY F. W. WHEELER & CO., (WEST BAY CITY, MICH., AND CUT IN TWO PARTS TO PERMIT OF DELIVERY AT NEW YORK VIA CANALS.

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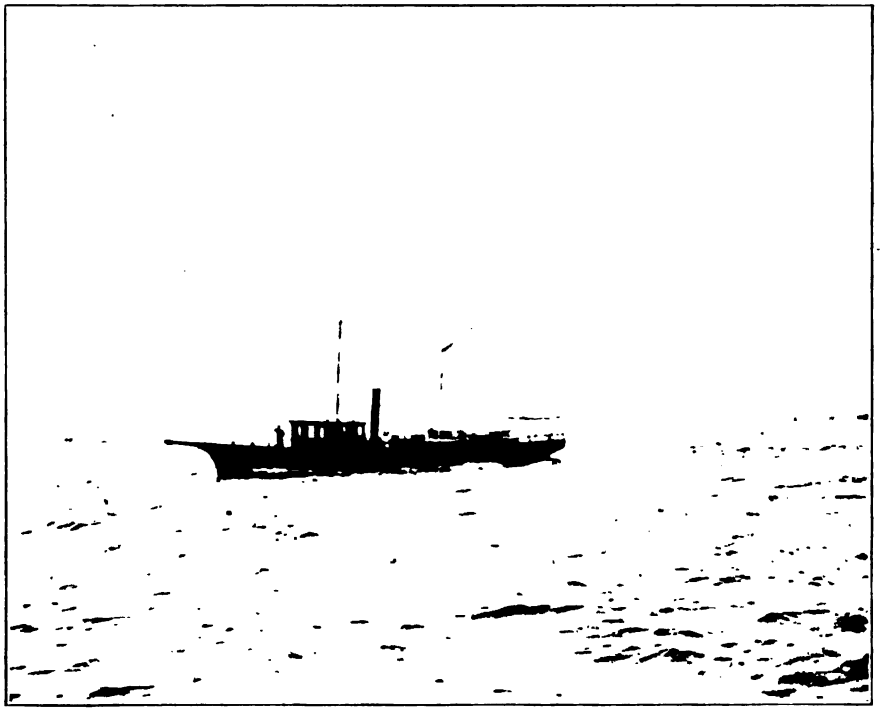
door, and wholly close the ashpit door. The coal on the bars prevents air from coming through them and impairing the draught, while the partial opening of the furnace door supplies air to the burning wood and directs the flame over the coal in the back end of the furnace, gradually heating it up to the point of ignition. After the wood is burning well, coal may be thrown upon it and the furnace door closed, the ashpit door being then opened. More coal is thrown on as soon as the fire will bear it, and the fire is gradually pushed back, till there is a full fire on the whole length of the bars. Remember that the fire must not be hurried, except in case of an emergency; it must be allowed to "come up," as it is called,



STEAM YACHT "CATHERINE."
EQUIPPED WITH 100 H. P. WATER TUBE BOILER.

very gradually, and to do this in the best manner, *put on only a little coal at a time*, the fire will be more even for it. And remember, also, that if the coal is lumpy it must be broken, so that no piece is larger than a man's fist. In very long boilers, unless care is taken, steam may be making at the furnace end while the water in the other end of the boiler is hardly warm. There is a set of cylinder boilers, 72 feet in length, where the engineer gets up his fires so gradually that two or three days are required to raise steam on them to the working pressure, after they have been lying idle. As he is equally as careful in other matters pertaining to the plant under his charge, it may not be surprising that his engines and boilers, though old, are in the best possible condition. This plant is in Stamford, Conn. The fires should always be kept level and of a uniform thickness, with the excep-

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ART INSTITUTE, CHICAGO, ILL.
EQUIPPED WITH 200 H. P. OF BOILERS.

tion that at the sides, corners, and at the bridge wall it must be enough thicker to prevent cold air from leaking through at these places. With anthracite coal the thickness of the fire should be from 6 to 8 inches generally; with bituminous coal, from 8 to 10 inches; and with coke, from 10 to 12 inches.

Proper Firing.

The firing is only done properly when the fuel is consumed in the best possible way, that is, when no more is burned than is necessary to produce the amount of steam required, and to keep the pressure uniform. Now, to attain this end, complete combustion must be attained in the furnace, and this is going on when the fuel is burning with a bright flame evenly all over the grate. Blue flame, dark spots and smoke are evidences of incomplete combustion, due to want of air, which ought to be supplied above the fuel in the furnace. When the ashpit is uniformly bright the fire must be burning well; but if it is dark, in patches or wholly, there must be ashes and clinker on the grate-bars, which should be removed at once. Ashes and clinker are also very apt to collect in the front corners of the furnaces, along the sides, and against the bridge wall, and these parts should be subject to special attention. Experience only can teach a man how to fire, with the various kinds of fuel and under the different styles of boilers, in the best and most economical manner, though there are a few general principles applicable in all cases.

It is of primary importance that the boiler-room and its appurtenances, as well as the boilers and their fixtures, and the necessary tools, should always be

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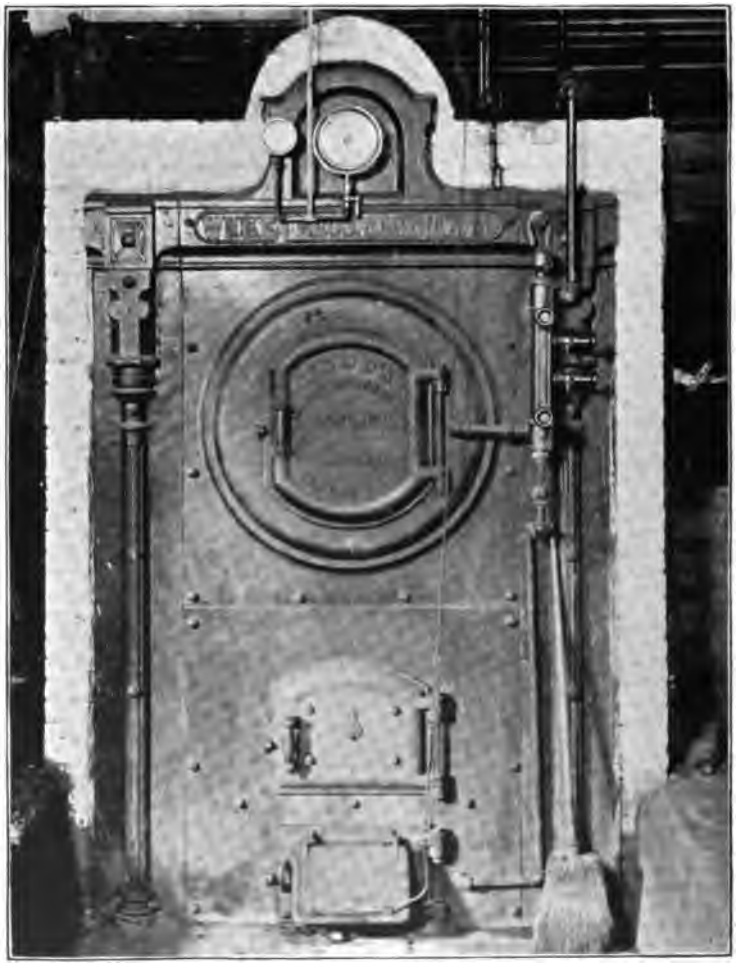
kept clean. Every tool should have its place, and be kept there when not in use, and if broken should be repaired at once. The boilers should be fired at regular intervals, and lightly, and it has been found better in many cases, especially with wide furnaces, to fire one side of the furnace at a time; of this, however, each fireman must be his own judge, as no two boilers can be fired exactly alike and produce the same results. When using a caking coal, a short time after firing, it will be found necessary to make use of the slice-bar to break the cake into fragments, in order to get the full benefit of the coal, but care must be taken to keep the furnace door open no longer than is absolutely necessary; and firing also should be done as quickly as possible, to avoid contraction of the boiler bottom from the cool air entering the furnace. The fire should not be stirred any more than is necessary, in order to avoid the waste from small coal dropping through the bars. With a strong chimney draught it is as well to par-



WOOD WATER TUBE BOILER AS LOCATED IN BOILER ROOM OF KORTLANDER & MURPHY BUILDING, GRAND RAPIDS, MICH.

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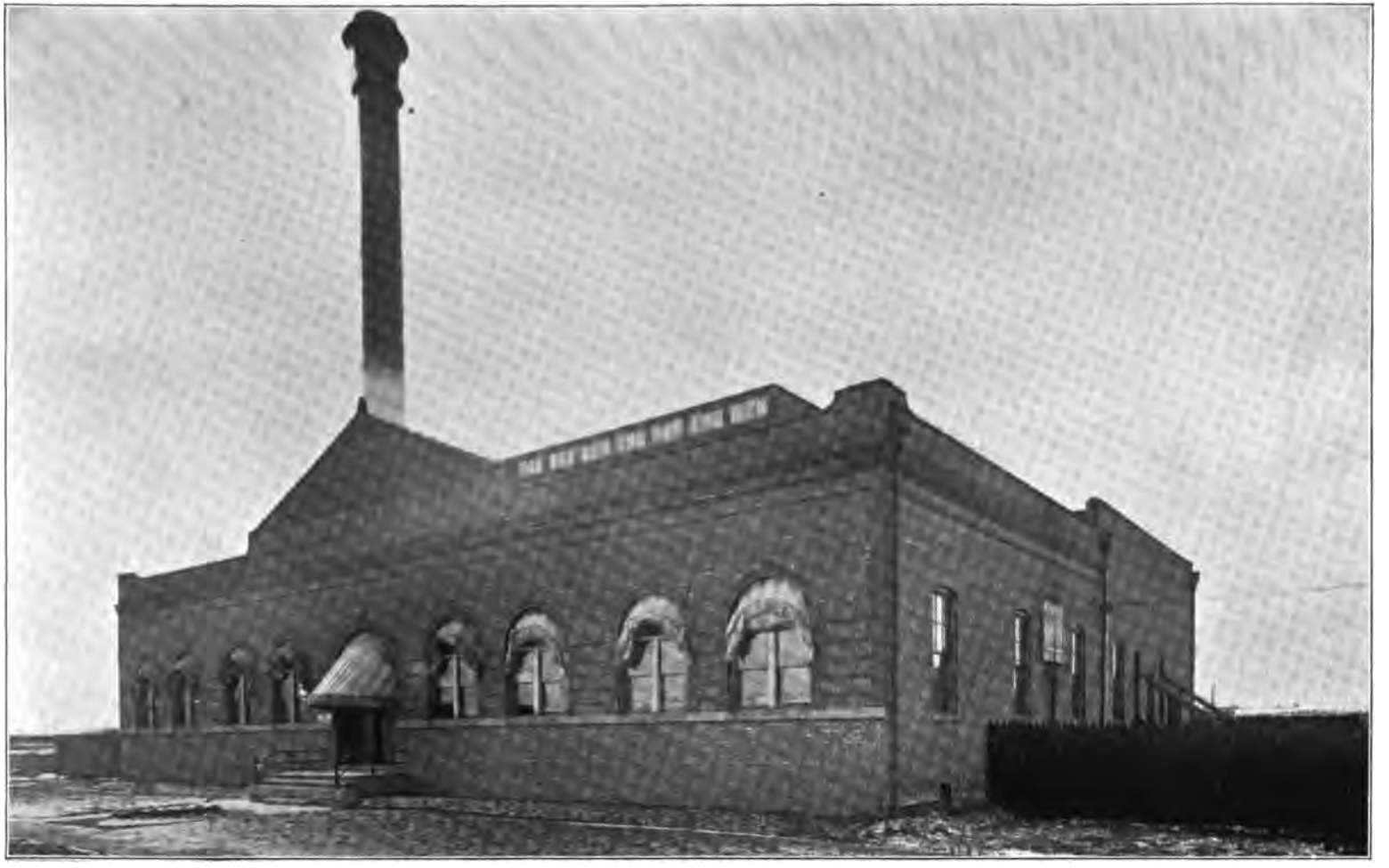

VIEW OF POWER HOUSE CALUMET ELECTRIC STREET RAILWAY COMPANY, CHICAGO, ILL.

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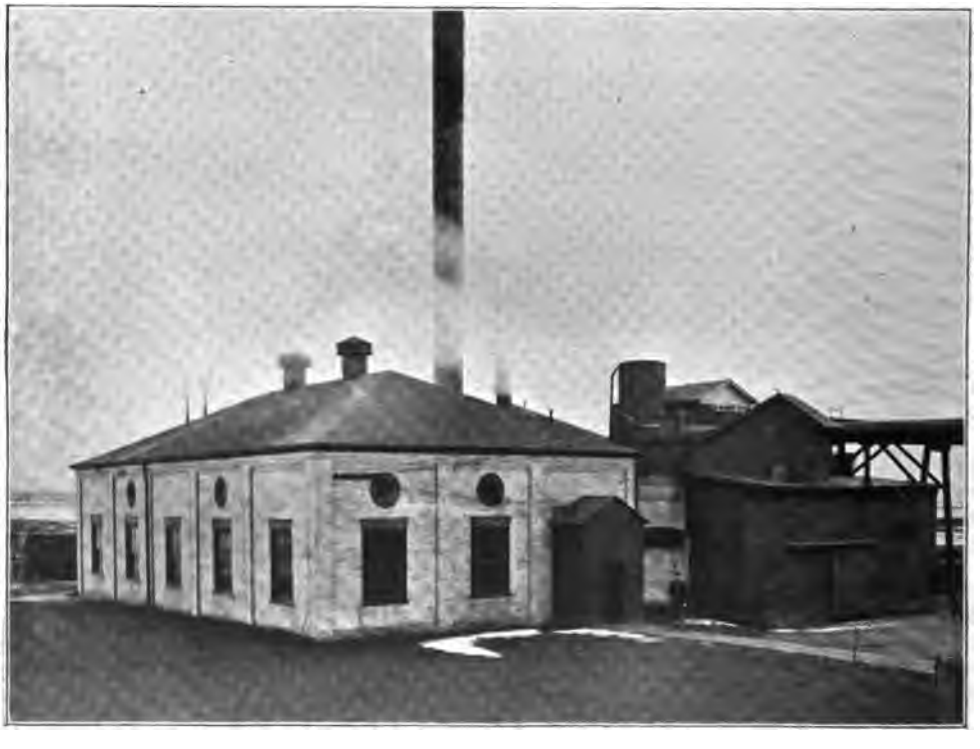
tially close the damper and also the ashpit doors when firing, to avoid contraction of the boiler sheets.

Cleaning Fire. When the clinkers and dirt accumulate to an extent sufficient to clog the draught, the fire should be cleaned. Now, in boilers with wide furnaces it is better, perhaps, to clean only one-half at a time, and let the fire burn up well on that side before attempting to clean the other half. A fire, with a good quality of coal, should run about twelve hours without cleaning. When there are several furnaces, all leading into the same chimney, they should be fired alternately, in order to keep the steam at a regular pressure and observe the greatest economy in fuel. The practice of wetting coal before throwing it into the furnace cannot be too severely condemned, as it is wasteful of heat and produces corrosion. The ashpits must be raked out frequently, and the air spaces between the bars must be kept free also. All ashes must be hauled to some distance from the boiler fronts and quenched, and then wheeled to the ash-pile.

The Damper. Never close the damper entirely while there is fire on the grates, as gas may collect in the flues, and an explosion might take place which would ruin the boiler. There is reason to believe that boiler explosions have been produced in this manner, and for this reason alone it is considered better to draw the fires at night, instead of banking them, by many engineers. But it is the opinion of the author that a banked fire, properly kept up, is conducive to longevity of the boiler, because of the less amount of contraction and



WATER WORKS AND ELECTRIC LIGHT PLANT, CADILLAC, MICH.
OPERATED BY 400 H. P. WOOD WATER TUBE BOILERS.

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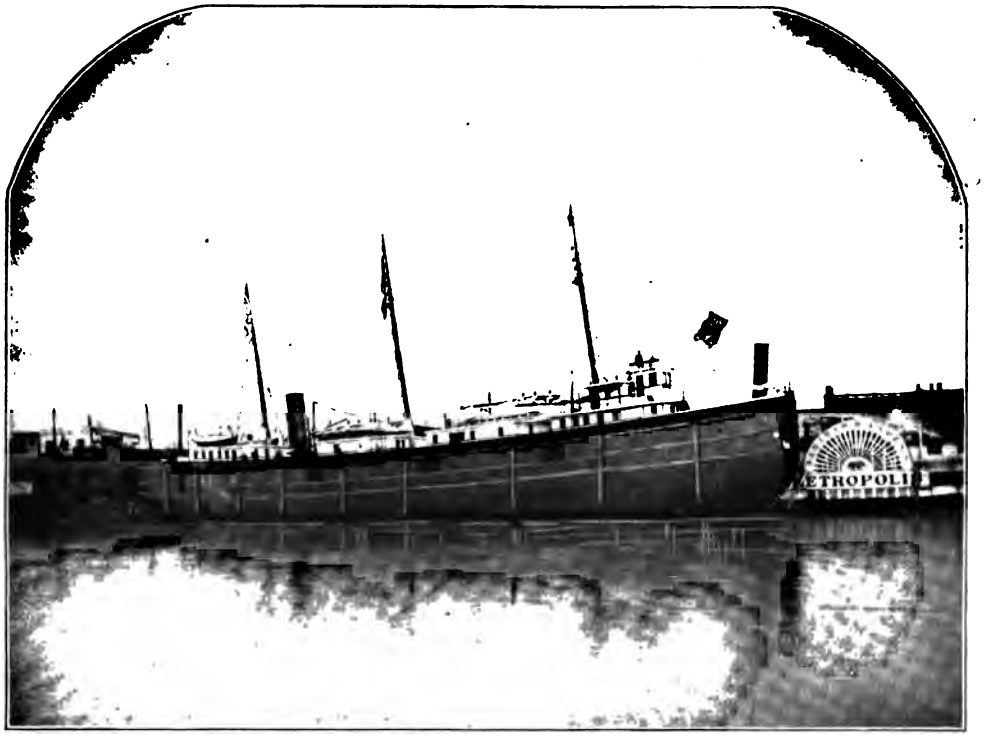
expansion induced, owing to difference in temperature. So far, we have considered only the handling of fires; now let us give some attention to other matters of importance.

Water Line. When a boiler is cold and filled with water, it will be found that after the fire is lighted and steam is raised to the regular pressure, the gauge cocks and water-glass show a higher water level than before the fires were started, which is owing to the expansion of the water by heat. If now the throttle be opened and the engine started, the water will rise still higher, in many boilers, showing a *false water-line*—for the water will drop to its proper level upon stopping the engine. This is owing to the violent ebullition going on in the



STEAMER No. 5, OWNED BY FLINT & PERE MARQUETTE RAILROAD COMPANY.
EQUIPPED WITH TWO 11 1-2 FT. X 12 FT. SCOTCH BOILERS, ALLOWED 160 LBS. PRESSURE.

boiler to supply the steam required, and which is being constantly drawn off—and it is more marked when the steam-room is small and the pressure high.

Feeding Water. A boiler should have its feed water supplied regularly and continuously, and the water-line should be kept at a regular height, and there should never be less than three or four inches in depth over the highest part of the furnaces, flues, or connections exposed to the flames or hot gases, but it is very bad practice to carry the water too high in a boiler, and as a general thing the above-mentioned depth should not exceed five inches above the "fire" line, so-called. In order to save fuel, a heater should be used, especially as it

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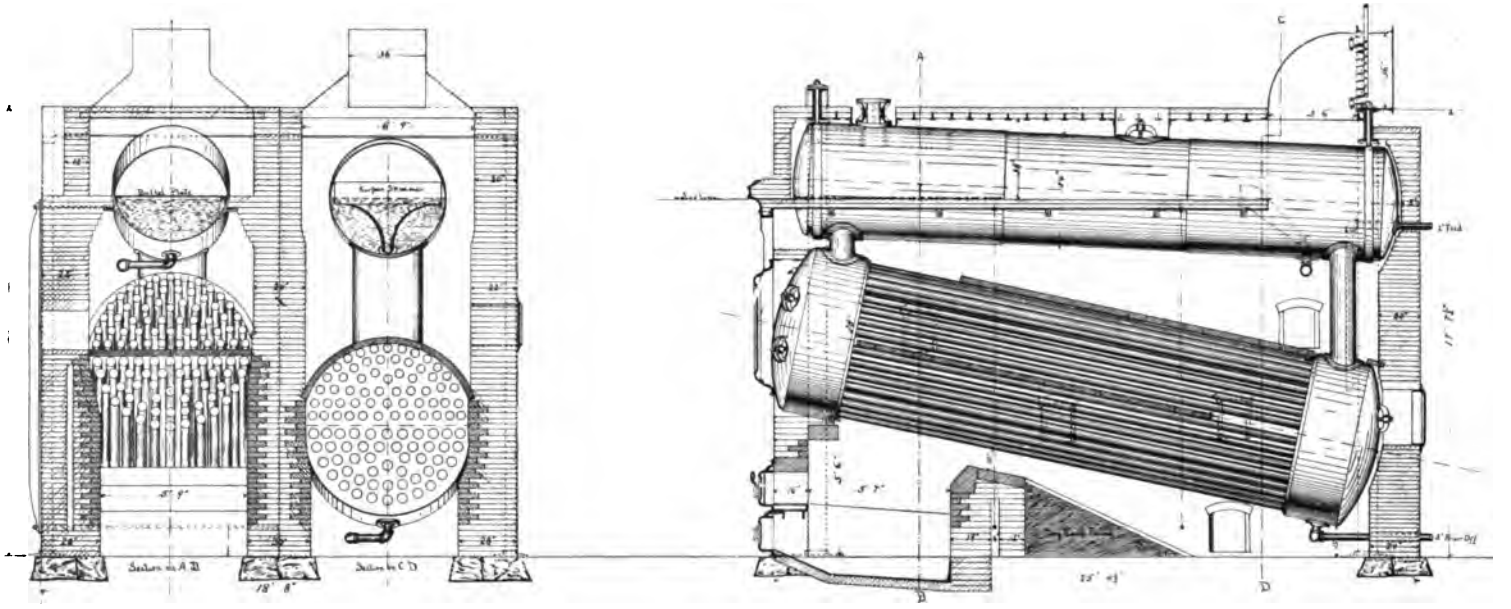

DRAWING.

Showing Ordinary Setting of 200 H. P. Wood Water Tube Boiler.

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also increases the longevity of the boiler, and diminishes the tendency to leakage at the tube ends.

Blowing off steam at the safety-valve, or opening the furnace doors, to prevent a rise of steam pressure, causes loss of heat, which is synonymous with waste of fuel, and will never occur where a boiler is properly managed, except upon an emergency. It is better to try the working of a safety-valve, which should be done once every day, by letting the steam rise gradually till the valve just "simmers," noting the pressure by the steam-gauge at that moment. Of course, you can raise it at any time by hand, but then you don't know *how much force you have exerted*, nor whether the steam would have raised it when it had attained the proper pressure.

Steam Pressure. The steam pressure should never be allowed to exceed its highest limit. If the steam-gauge shows that the steam pressure is rising rapidly, and that there is danger of exceeding the limit, water should be fed in at once, and the draught checked by the damper and ashpit doors; and if, in spite of this, the pressure should exceed the limit, the furnace doors should be opened, the feed put on more strongly, and the blow-cock partially opened, watching the water-line very sharply, as shown in the glass-gauge, and continually trying the gauge-cocks. But should it happen that the water is so low as to be dangerous, the pump must not be started, though if it is already in motion it may be allowed to continue; the blow-cock must not be meddled with, but the furnace doors must be opened, and fresh coal, or better still, wetted small coal and ashes, must be thrown on the fire, and then in a few minutes the boiler will generally be cool enough to pump up. After such an incident, the tube ends should be carefully examined in the upper rows for leaks.

Blowing Out. The gauge-glass should be blown through several times every day, to see that it is not choked, and it is a very good plan to try the gauge-cocks every fifteen minutes during the day. Of course this necessitates a clock, but no fire-room should be without one; it is as indispensable as the fire tools.

Foaming is a violent ebullition of the water in a boiler, which results in "priming," or the carrying of the water, in the state of fine spray, with the steam into the engine cylinder, often knocking out a cylinder-head, and rapidly lowering the water level in the boiler, sometimes so much so as to be dan-

Foaming. gerous. Foaming is generally caused by irregularity in firing or feeding; impure water, especially if it be greasy; contracted steam space; too small extent of area at the water-line; from the tubes being crowded together; the boiler not being clean; the throttle or safety-valve being opened too suddenly; and, in marine boilers, changing the feed-water from salt to fresh, or the reverse. It is generally shown in the glass-gauge by a sudden rising or falling of the water, or by a boiling or showering of the water down through the glass, and by a peculiar sputtering sound given upon opening the gauge-cock. It can be overcome by partially closing the throttle, opening the furnace door, and feeding strongly; sometimes, however, it is necessary to blow out a little water from the boiler, but this should not be resorted to except in an extreme case.

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Defective Feed Pump.

In case the feed pump works badly there may be several causes for it, such as clogging of the strainer, broken or leaky valves, leaky packing, leaky or choked pipes, the pump being hot, the feed water being too hot. The trouble should be ascertained as quickly as possible, and remedied at once.

A boiler needs cleaning out more or less frequently during each year, dependent upon the amount of impurities in the feed water. When a fire is hauled, the stop-valve on the steam-pipe should be shut, the ashes and cinders quenched and wheeled to the ash pile, the furnace and ashpit doors and the damper should be closed, and the steam blown off at the safety-valve till there is only about five pounds pressure, and then it should be lowered to its seat. On no account should the water be blown out of the boiler; it should remain there until it is cool, and then must be allowed to run out through the blow-cock. When the boiler is empty the man-holes and hand-holes may be opened, and the boiler must be examined internally, the scale must be knocked off with light blows of a pick, or scraped with bars and chisels, or loosened with angular wire chains, etc., and the boiler must be washed clean with water. The scale should be removed as soon as possible after the water has been let out of the boiler, before it has time to dry and harden. Any repairs required by the braces, or at other points, should be made, and the boiler closed up. Then the blow-cock should be taken apart, the plug cleaned, oiled, and made to work water-tight and easily; the check-valves should be examined and made tight; the feed-pipe and blow-out pipe should be examined and cleared of sediment, if any exists. The safety-valve should be examined, the pins taken out, cleaned and oiled, and the valve ground in, if it is leaky. The gauge-cocks should be examined, cleaned, and ground in, if necessary; the glass water-gauge should be examined and put into good condition; and advantage should be taken of this opportunity to send the steam-gauge to the maker and have it put into thorough condition. The flues and connections should be swept, and the boiler bottom scraped with a wire brush; the furnaces should have the bars taken out, and the brick lining put into good condition, the ashpits cleaned and the bars replaced, renewing such as are badly warped or broken. The boiler is now ready for filling with water, which should be done at once, and then it should be examined carefully for leaks, which, if found, should be repaired at once, before the boiler is put into use again. If, however, it is not intended to use the boiler for some time, it will be well to drain all the water out of it, and to dry it thoroughly by pans of charcoal, and then set a pan or two of lime into the boiler, and close it tightly to prevent oxidation.

Cleaning Out.

A full set of fire tools, consisting of a shovel, slice-bar, T-bar, pricker, hoe, coal hammer, and devil's claw, should always be kept in the fire-room, together with a broom and dust brush, and also a chipping hammer, a flat and diamond-point chisel, and wrenches to fit the nuts and bolts about the boiler, a monkey-wrench and screw-driver. A wheelbarrow is sometimes needed, also.

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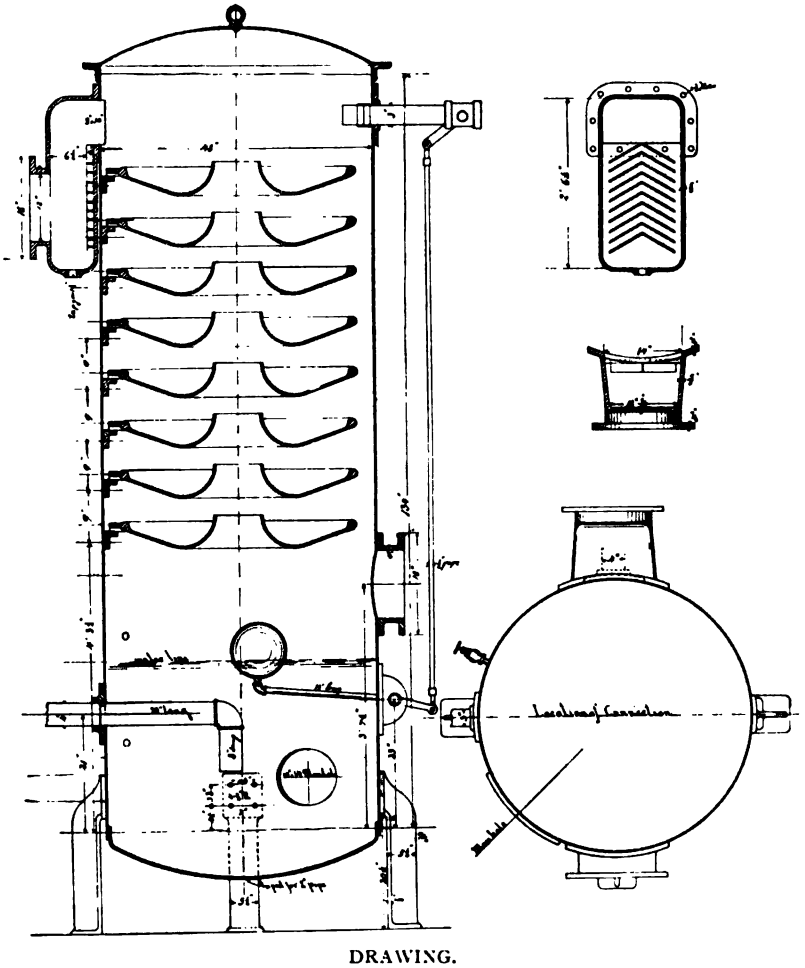
HEATING FEED WATER.

THE marked economy of heating feed water before entering the boiler, to a temperature as high as possible by the utilization of some heat otherwise wasted, has been recognized and is now well understood. The waste heat usually employed for this purpose is, first: that contained in the exhaust steam from non-condensing engines; and, second: that found in the waste products of combustion after leaving the boilers and just before entering the chimney. To effect the first, what is termed a "Heater" is used; for the second, an "Economizer."

What Waste Heat to Utilize.

The following table, taken from Nystrom, shows the percentages of loss or gain of power by diffreent temperatures of the feed water being heated or cooled. The vertical column designates the temperature of the feed water entering the boiler. The first horizontal column shows the temperature from which the water is heated or cooled. The sign + indicates gain; — loss.



DRAWING.
Open Heater and Purifier.

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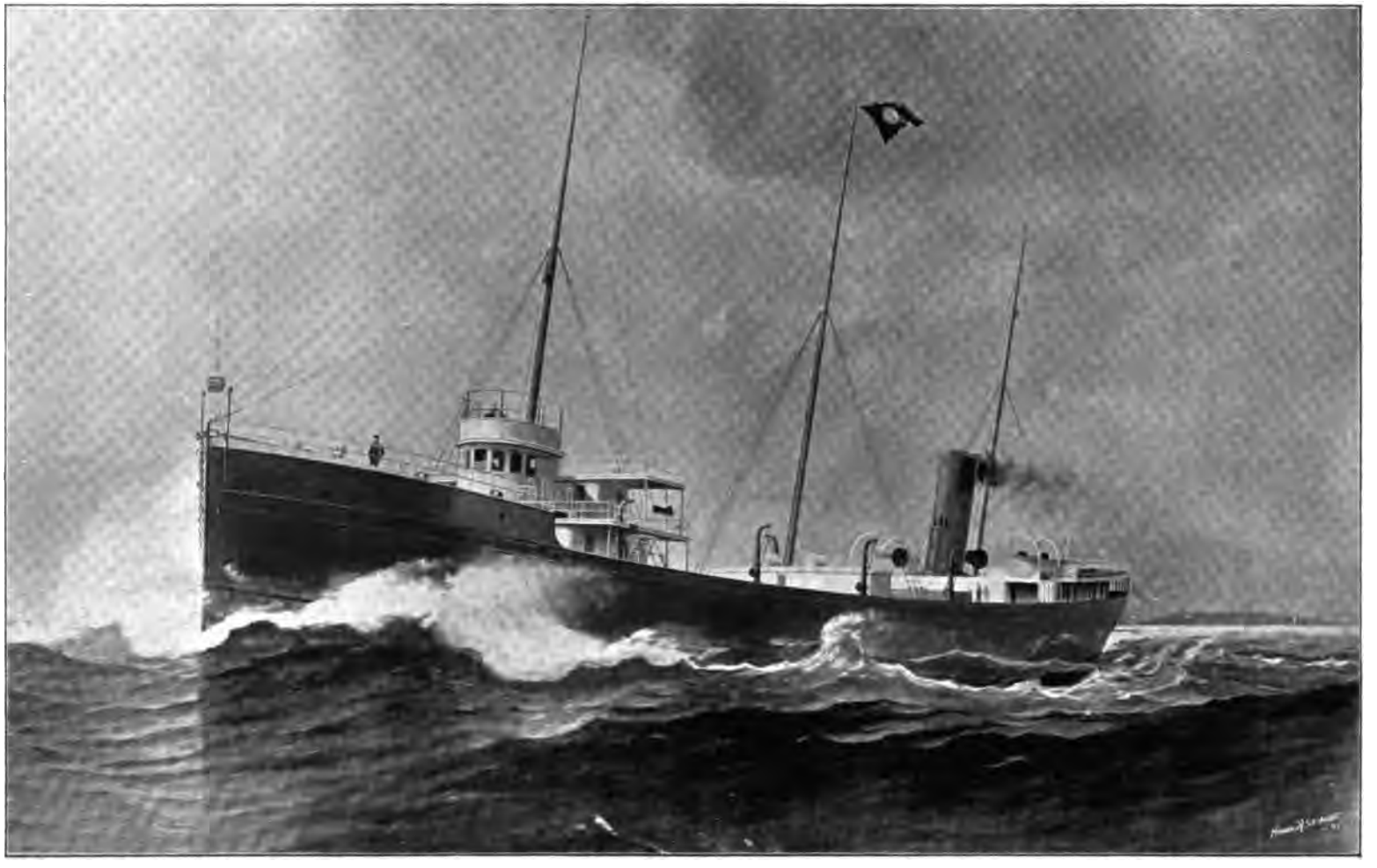

STEEL STEAMER "W. H. GRATWICK," OF THE NEW YORK CENTRAL & HUDSON RIVER R. R. LINE
BOILERS, TWO 13 FT. X 12 FT., CARRYING 170 LBS. PRESSURE.

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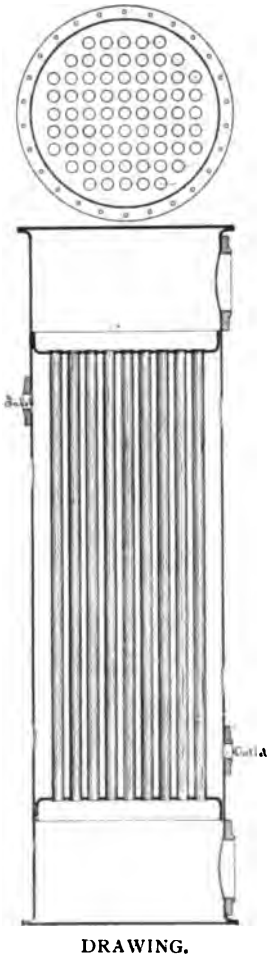
TEMPERATURE FROM WHICH THE FEED WATER IS HEATED OR COOLED.

Temperature Entering Boil'r.	32	40	50	60	70	80	100	120	140	160	180	200
32	0.0	— 1.	— 1.5	— 2.	— 3.4	— 4.4	— 6.5	— 9.	—11.	—13.	—16.	—19.
40	+ 1.	0.0	— 0.5	— 1.	— 2.4	— 3.4	— 5.5	— 8.	—10.	—12.	—15.	—18.
50	+ 1.5	+ 0.5	0.0	— 0.5	— 2.	— 3.	— 4.	— 7.	— 9.	—11.	—14.	—17.
60	+ 2.	+ 1.	+ 0.5	0.0	— 1.4	— 2.4	— 3.5	— 6.	— 8.	—10.	—14.	—16.
70	+ 3.4	+ 2.4	+ 2.	+ 1.4	0.0	— 1.	— 3.	— 5.	— 7.	— 9.	—13.	—15.
80	+ 4.4	+ 3.4	+ 3.	+ 2.4	+ 1.	0.0	— 2.	— 4.	— 6.	— 8.	—12.	—14.
90	+ 5.4	+ 4.4	+ 4.	+ 3.4	+ 2.	+ 1.	— 1.	— 3.	— 5.	— 7.	—11.	—13.
100	+ 6.5	+ 5.5	+ 5.	+ 4.4	+ 3.	+ 2.	0.0	— 2.	— 4.	— 6.	— 9.5	—12.
110	+ 7.6	+ 6.6	+ 6.	+ 5.6	+ 4.2	+ 3.2	+ 1.	— 1.	— 3.	— 5.	— 8.	—11.
120	+ 8.7	+ 7.7	+ 7.	+ 6.7	+ 5.3	+ 4.3	+ 2.2	0.0	— 2.	— 4.	— 7.	—10.
130	+ 9.8	+ 8.8	+ 8.3	+ 7.8	+ 6.4	+ 5.4	+ 3.3	+ 1.	— 1.	— 3.	— 6.	— 9.
140	+11.	+10.	+ 9.	+ 9.	+ 8.	+ 7.	+ 4.5	+ 2.	0.0	— 2.	— 5.	— 8.
150	+12.	+11.	+10.	+10.	+ 9.	+ 8.	+ 5.5	+ 3.	+ 1.	— 1.	— 3.	— 7.
160	+13.	+12.	+11.	+11.	+10.	+ 9.	+ 6.5	+ 4.	+ 2.	0.0	— 2.	— 6.
170	+15.	+14.	+12.	+12.	+12.	+11.	+ 8.	+ 6.	+ 4.	+ 2.	— 1.	— 4.
180	+16.	+15.	+14.	+14.	+13.	+12.	+ 9.	+ 7.	+ 5.	+ 3.	0.0	— 3.
190	+17.	+16.	+15.	+15.	+14.	+13.	+10.	+ 8.	+ 6.	+ 4.	+ 1.	— 2.
200	+19.	+18.	+17.	+17.	+16.	+15.	+12.	+10.	+ 8.	+ 6.	+ 3.	0.0
212	+20.	+19.	+18.	+18.	+17.	+16.	+14.	+11.	+ 9.	+ 7.	+ 4.	+ 1.

The accompanying cut shows a style of Heater and Purifier which we are prepared to build in sizes up to 800 H. P.



DRAWING.
Small Closed Heater.

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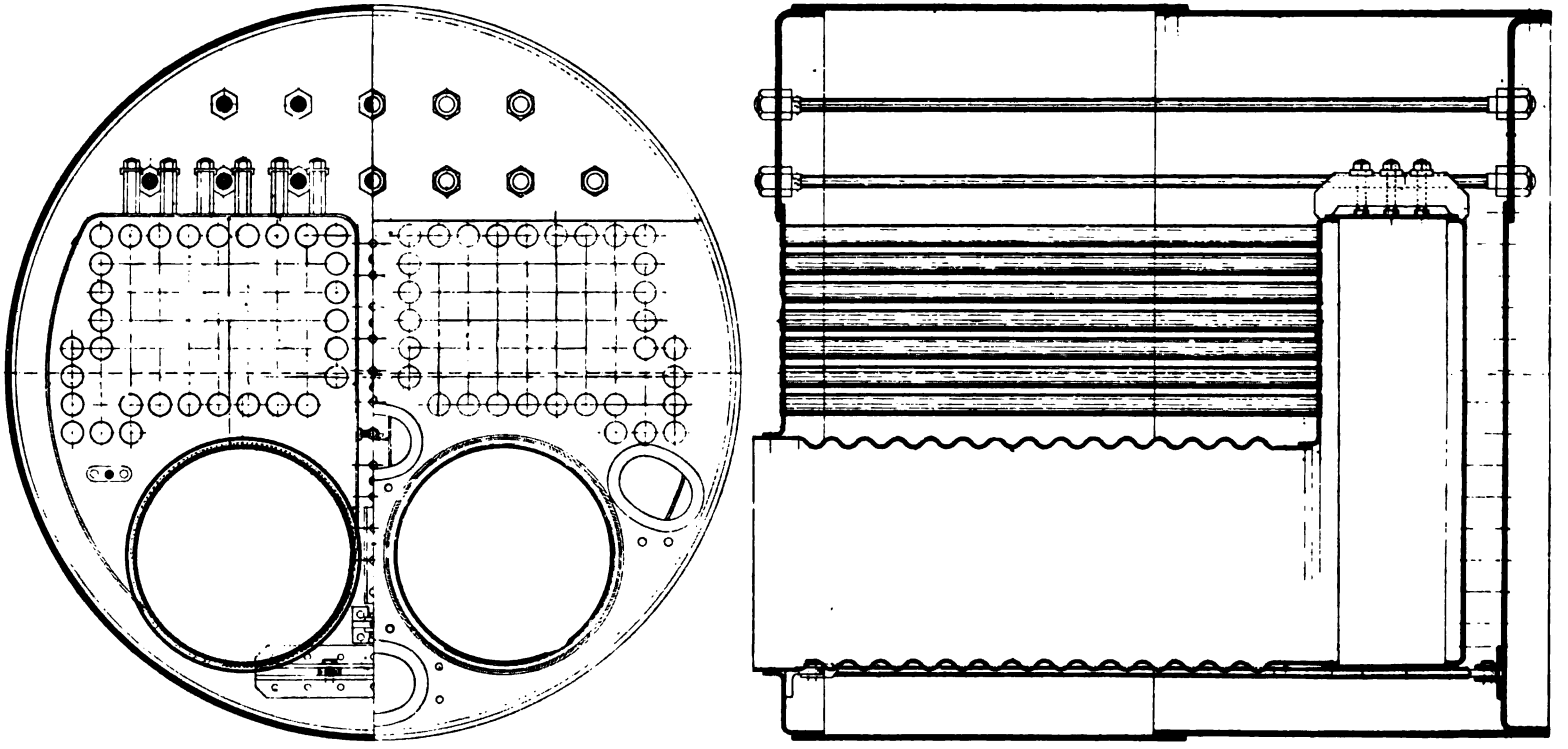

DRAWING.

Scotch Marine Boiler with Two Furnaces. No Dome.

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STEAM BOILER AND PIPE COVERINGS.

ONE of the large thermodynamic losses which presents itself in the transference of steam in pipes or other vessels is that lost by radiation, and with large boilers and systems of pipe work this loss becomes one of great magnitude, not only in fuel waste, but also by the water of condensation forming an obstruction to the proper working of engines.

Thos. Box (A Practical Treatise on Heat), says: "That for ordinary atmospheric temperatures and small differences between the radiant and absorbent bodies, the loss of heat by radiation is not great, and is simply proportional to that difference of temperature, but for high temperatures, and great differences of temperature between the radiant and absorbent bodies, the loss of heat becomes exceedingly great. The loss of heat increases also in a much more rapid ratio than the difference of temperature.

The following table, taken from Box (Thos. Box on Heat), will show the loss of heat in B. T. U. from different sized pipes, by radiation, supposing the temperature of the room or absorbent body to be at 60 degrees, and using different radiant temperatures, or those of the steam in the pipe:

OCEAN TUG "YULU."
PLYING ON SOUTH AMERICAN COAST. HAS FIRE BOX MARINE BOILER 8 FT. X 14 FT., CARRYING 150 LBS. PRESSURE.

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Mean Temp. of the Pipe.	Temp. of the Air.	Difference.	Units of Heat per Square Foot of Surface per Hour.				Units of Heat per Foot run of Pipe per Hour.			
			2 in.	3 in.	4 in.	6 in.	2 in.	3 in.	4 in.	6 in.
300	60	240	616	574	553	531	403	545	669	938
280	60	220	543	505	486	467	355	480	587	825
260	60	200	477	443	426	409	312	421	515	723
240	60	180	414	385	370	355	271	366	448	627
220	60	160	356	330	317	314	233	313	384	537
210	60	150	327	303	291	279	214	287	352	493
200	60	140	299	277	266	256	195	263	322	452
190	60	130	271	251	241	231	177	239	292	408
180	60	120	245	227	218	209	160	216	264	369
170	60	110	220	204	196	188	144	194	237	332
160	60	100	196	181	174	167	128	172	210	295
150	60	90	172	159	153	147	112	151	185	260

Thus, with 35 lbs. pressure, the temperature of the steam 280 degrees, the loss of heat with a 4 inch pipe would be 587 units per foot run per hour, and as a Horse Power requires 33,327 B. T. U. per hour, we find that a 4 inch pipe 100 feet long would be $587 \times 100 \div 33{,}327 = 1.7$ Horse Power.

The method adopted for preventing, in a measure, this source of loss, is by the application of some non-conducting material to the radiant body, having for its object the protection of the external surfaces from loss of heat and from any injurious action liable to occur in consequence of their exposure. There are various kinds of such coverings, and care should be taken in the selection to see that they do not of themselves set up any deteriorating effect, and cause injury more serious than that which they allay.

The experiments of Mr. C. E. Emery, (Trans. Am. Soc. Mech. Eng.), give the following as the relative values of available covering materials:

Non-Conductor.	Value	Non-Conductor.	Value
Wood Felt	1.000	Loam, Dry and Open	.550
Mineral Wool No. 2	.832	Slacked Lime	.480
Mineral Wool No. 2 with Tar	.715	Gas House Carbon	.470
Sawdust	.680	Asbestos	.363
Mineral Wool No. 1	.676	Coal Ashes	.345
Charcoal	.632	Coke in Lumps	.277
Pine Wood across Fibre	.553	Air Space, undivided	.136

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TESTS.

UNIVERSITY OF MICHIGAN,
ANN ARBOR, MICH.

M. E. COOLEY,
PROFESSOR OF MECHANICAL ENGINEERING.

ANN ARBOR, May 20, 1892.

Messrs. Wickes Bros.,
Saginaw, East Side, Mich.

GENTLEMEN:—Please accept my apology for delaying my reply to yours of April 16th, also of 6th inst. I have been ill for several weeks, and since getting on my feet again have had to care for my class work in college. Correspondence, in consequence, has greatly suffered. I will endeavor to advise shortly of the earliest date which will be possible for me to come to Saginaw to finish up the boiler tests recently begun by Professor Wagner. I greatly regret the delay, which cannot have inconvenienced you more than myself. I congratulate you upon the results of the tests made by Professor Wagner. I trust that the other experiments will show even better results. I beg to remain,

Yours very truly,

Signed, M. E. COOLEY.

REPORT OF TEST MADE BY PROF. F. C. WAGNER OF THE FIRST WOOD PATENT WATER TUBE BOILER BUILT BY WICKES BROS., AND WHICH IS LOCATED IN OUR OWN PLANT.

The boiler upon which the following tests were made was one of a battery of two similar boilers regularly supplying steam to the various engines about the works. As the demand for steam was somewhat irregular and at times excessive, the adjacent boiler was also kept under steam, and drawn upon as occasion demanded.

The scales upon which the feed water was weighed were brought from the laboratory of the University of Michigan, and were tested at the trial by a fifty-pound standard weight, being found correct. The scales upon which the coal was weighed were also tested and found correct. The steam gauge was compared with a test gauge, which, in turn, was compared with the standard at the University of Michigan both before and after the test. The pyrometer was standardized by comparison with a mercurial thermometer after the test. The barometer was an æneroid belonging to the University, and was compared with a mercurial barometer both before and after the test. The thermometers were also brought from the University.

DESCRIPTION OF BOILER.

The **Wood's Patent Water-Tube Boiler** has a bank of inclined tubes between two cylindrical headers. To the tops of the headers is connected, by short vertical cylinders, a horizontal drum, of about two-thirds the diameter of the

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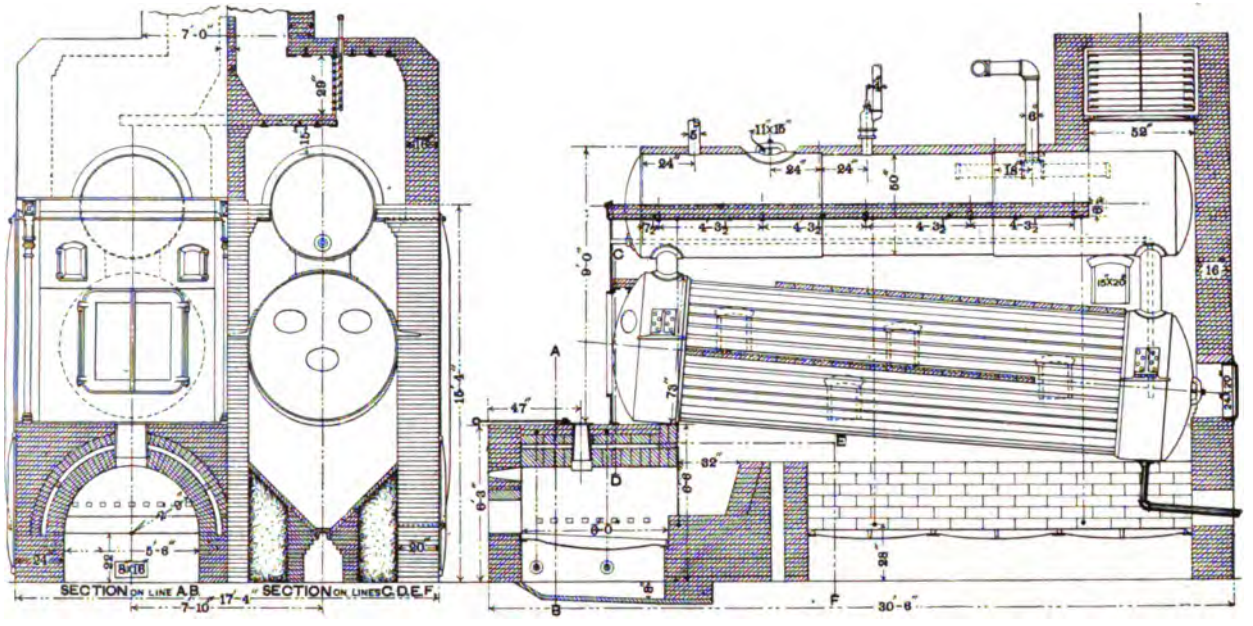

DRAWING.

Wood Water Tube Boiler supported by Lugs.

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headers, and extending the entire length of the boiler. The tubes are divided into two sections by a partition of fire-brick extending from the front header to within 39 inches of the back header. An arch of fire-brick laid on top of the tubes forms a second partition, extending from the back header to within 45 inches of the front header. The furnace gases are thus compelled to pass to the back of the boiler in contact with the lower section of the tubes, then to the front in contact with the upper section, and back again to the uptake in contact with the lower half of the drum. The furnace was fitted with a Dorrance rocking grate.

DIMENSIONS OF BOILER.

Type of boiler	Water Tube.
Number of boilers	1
Diameter of headers, inches	66.
Length of headers, inches	42.
Diameter of tubes, inches	4.5
Length of tubes, feet	15.75
Number of tubes	70
Inclination of tubes	1 in 12
Arrangement of tubes	Concentric Circles.
Diameter of drum, inches	48.
Length of drum, feet	22.5
Water space, cubic feet	397.67
Steam space, cubic feet	136.72
Steaming surface of water, square feet	86.

HEATING SURFACE—	
Headers, one-half shell and ends, square feet	142.4
Tubes, entire surface, square feet	1298.7
Cylinder, one-half shell and ends, square feet	283.3
Vertical connecting cylinders, square feet	14.7
Total square feet	1739.1
FURNACE—	
Width, feet	5.583
Length, feet	4.836
Area, square feet	27.
CHIMNEY—	
Height, feet	109.5
Diameter, feet	4.333
Draught area, square feet	14.747
Area of calorimeter smallest draught area, square feet	8.67
Ratio of grate area to calorimeter	3.114
Ratio of heating surface to grate area	64.4

EFFICIENCY TEST.

The test was begun by hauling the fire, and starting afresh with weighed kindlings and coal. At the end of the test the fire was hauled, and the coal found was credited to the boiler. The fuel used was "Massillon" bituminous coal. The larger pieces were broken up, and the coal was weighed out in charges of 100 lbs. each. The firing was done by the regular fireman, assisted by Mr.

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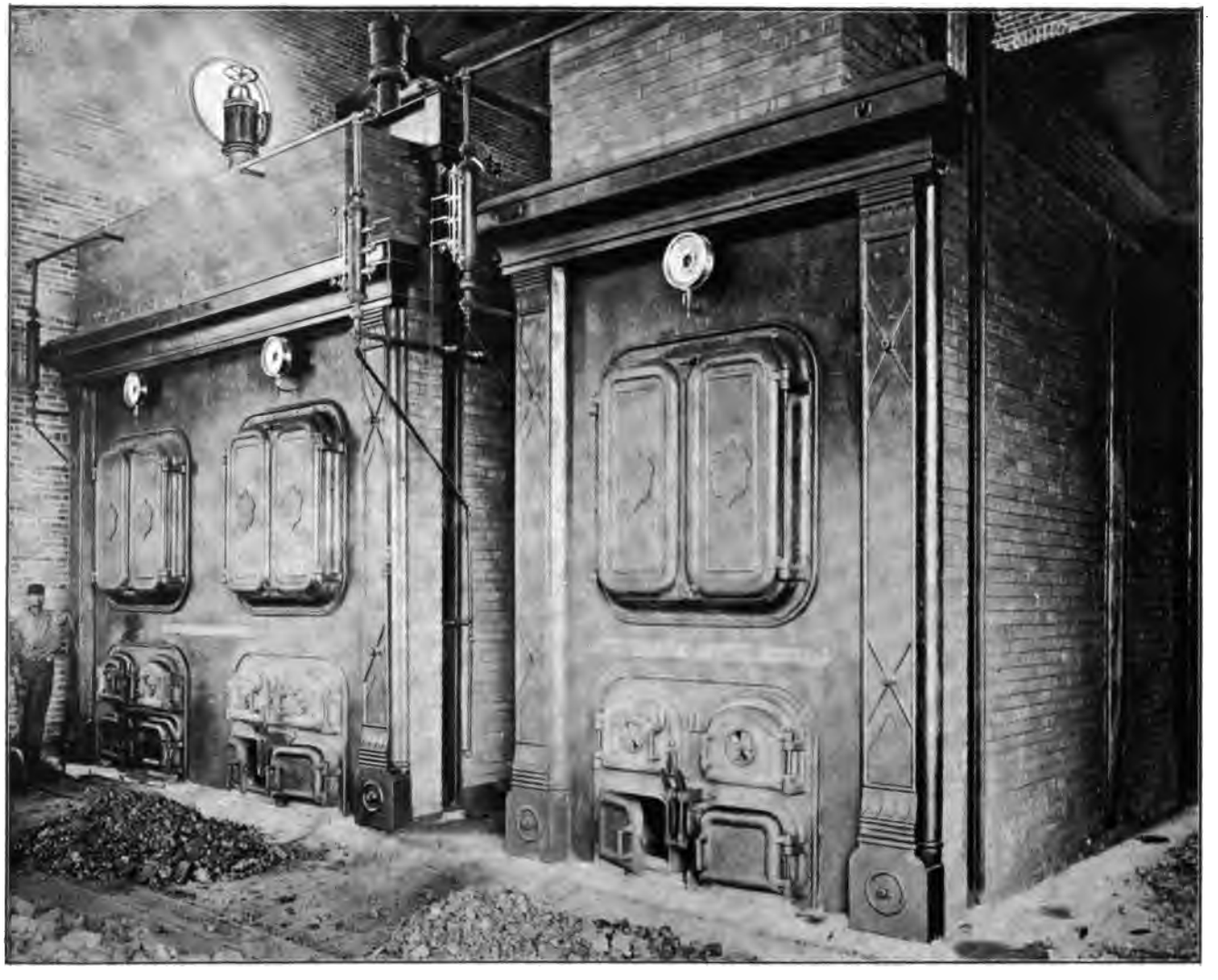

INTERIOR VIEW OF BOILER ROOM IN THE SAGINAW CONSOLIDATED STREET RAILWAY PLANT.

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Baker. At one time considerable clinker was found, clearing the grate from which, undoubtedly, caused some loss of heat.

The feed-water was measured by turning it into a tank upon a pair of platform scales, weighing it, and then emptying it into a second tank, from which the feed-pump took its supply. The level of the water in the lower tank was noted at the start, and every two hours, as well as at the end of the test, the water was brought up to the same level as at the start. The temperature of the feed-water was measured just before it entered the boiler. The temperature of the chimney gases, and also the chimney draught, were measured at the base of the stack, about 27 feet above the floor of the boiler-room. The quality of the steam was determined by a Barrus universal calorimeter, placed as close as possible to where the main steam-pipe takes off from the boiler. The steam pressure, height of water in glass, temperature of feed, draught-gauge, and pyrometer were observed every fifteen minutes during the test. The temperatures of the boiler-room and the external air and the barometer readings were taken hourly. Calorimeter tests of an hour's duration were made at 12.45, at 3.45, and at 6.45. During the last six hours of the test the coal used was very wet, water having dripped upon the coal, freezing as it dripped. A sample of the wet coal was taken and the moisture determined, and a proper allowance has been made. The observations were taken every twenty minutes, instead of every fifteen minutes.

PERFORMANCE OF BOILER MARCH 18.

DURATION OF TEST, hours		10.
FUEL—"Massillon" bituminous coal.		
Dry coal fired	pounds	2600.
Wood fired	"	100.
Coal equivalent to wood	"	40.
Coal left on grate at start, estimated	"	50.
Wet coal fired	"	3400.
Moisture in wet coal	"	204.
Equivalent dry coal	"	3196.
Total dry coal and wood fired	"	5886.
Coal on grate at end of test	"	134.
Total coal charged to test	"	5752.
Ashes and clinkers	"	545.
Cumbustible	"	5207.
Percentage of ashes and clinkers	"	9.47
PRESSURES—		
Steam pressure; average gauge, pounds		99.06
Barometer; average, inches		29.407
Barometer; average, pounds		14.42
Steam pressure; average absolute, pounds		113.48
Draught; average, inches of water		.510
TEMPERATURES; Average, degrees Fahr.—		
Feed-water		38.61
Flue gases		312.7
Boiler room		76.5
External air		26.6

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WATER LEVEL IN BOILER, above bottom of glass, inches—	
Height at beginning of test	5.0
Height at end of test	5.0
Average height during test	6.05
WATER, as weighed, pounds—	
Total water weighed to boiler	41728.
Quality of steam	Superheated.
Degrees of superheat, Fahrenheit	3.7
EVAPORATION UNDER ACTUAL CONDITIONS—	
Number of pounds of water per pound of coal	7.255
Number of pounds of water per pound of combustible	8.014
Factor of evaporation	1.2214
EVAPORATION FROM AND AT 212° FAHR.—	
Total number of pounds of water	50966.5
Number of pounds of water per pound of coal	8.861
Number of pounds of water per pound of combustible	9.788
RATE OF COMBUSTION, per hour—	
Number of pounds of coal burned	575.2
Number of pounds of coal per square foot grate area	21.3
Number of pounds of coal per square foot heating surface	.331
RATE OF EVAPORATION UNDER ACTUAL CONDITIONS, per hour—	
Number of pounds of water evaporated	4172.8
Number of pounds of water evaporated per square foot of grate area	154.5
Number of pounds of water evaporated per sq. ft. of heating surface	2.399
RATE OF EVAPORATION FROM AND AT 212° FAHR., per hour—	
Number of pounds of water evaporated	5096.6
Number of pounds of water evaporated per square foot of grate area	188.77
Number of pounds of water evaporated per sq. ft. of heating surface	2.931
Horse-power developed, on the basis of 34.5 lbs. per horse-power	147.73
ANALYSIS OF COAL—	
Moisture, per cent	4.11
Volatile carbon, per cent	39.75
Fixed carbon, "	47.70
Ash, "	7.58
Sulphur, "	.86
Total	100.00
HEAT EFFICIENCY—	
Number of heat units in one pound of coal	12680.
Number of heat units transmitted to water in boiler per lb. of coal	8559.7
Number of heat units passing to chimney or lost by radiation	4120.3
Percentage of heat transmitted to water in boiler	67.51
Percentage of heat lost	32.49

CAPACITY TEST.

On March 19th a capacity test of three hours duration was made. The boiler had been cleaned previously, and was in good condition. The same observations were taken as in the preceding tests. The test was started with a

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heavy fire on the grate and ended with as nearly as possible an equal fire. On account of the shortness of the test the economic results can only be considered as approximately correct. As on the previous day, the coal was wet; a similar allowance has been made for the moisture. The percentage of ash was taken to be that found by the chemical analysis given above.

PERFORMANCE OF BOILER MARCH 19th.

DURATION OF TEST, hours		3
FUEL—"Massillon" bituminous coal.		
Wet coal fired	pounds	4100.
Moisture in wet coal	"	246.
Equivalent dry coal	"	3854.
Combustible	"	3562.
PRESSURES—		
Steam pressure; average gauge, pounds		102.72
Barometer; average, inches		29.111
Barometer; average, pounds		14.294
Steam pressure; average absolute, pounds		117.014
Draught; average, inches of water		.371
TEMPERATURES; Average, degrees Fahr.—		
Feed-water		37.95
Flue gases		428.5
Boiler-room		60.
External air		28.3
WATER LEVEL IN BOILER, above bottom of glass, inches—		
Height at beginning of test		10.25
Height at end of test		10.50
Average height during test		9.86
WATER, as weighed—		
Total water weighed to boiler		22314.5
Percentage of moisture in steam		0.29
Total moisture in steam, pounds		64.7
Water actually evaporated, pounds		22249.8
EVAPORATION UNDER ACTUAL CONDITIONS—		
Number of pounds of water per pound of coal		5.773
Number of pounds of water per pound of combustible		6.246
Factor of evaporation		1.2210
EVAPORATION FROM AND AT 212° FAHR.—		
Total number of pounds of water		27167.
Number of pounds of water per pound of coal		7.049
Number of pounds of water per pound of combustible		7.627
RATE OF COMBUSTION, per hour—		
Number of pounds of coal burned		1284.7
Number of pounds of coal per square foot grate area		47.58
Number of pounds of coal per square foot heating surface		0.738

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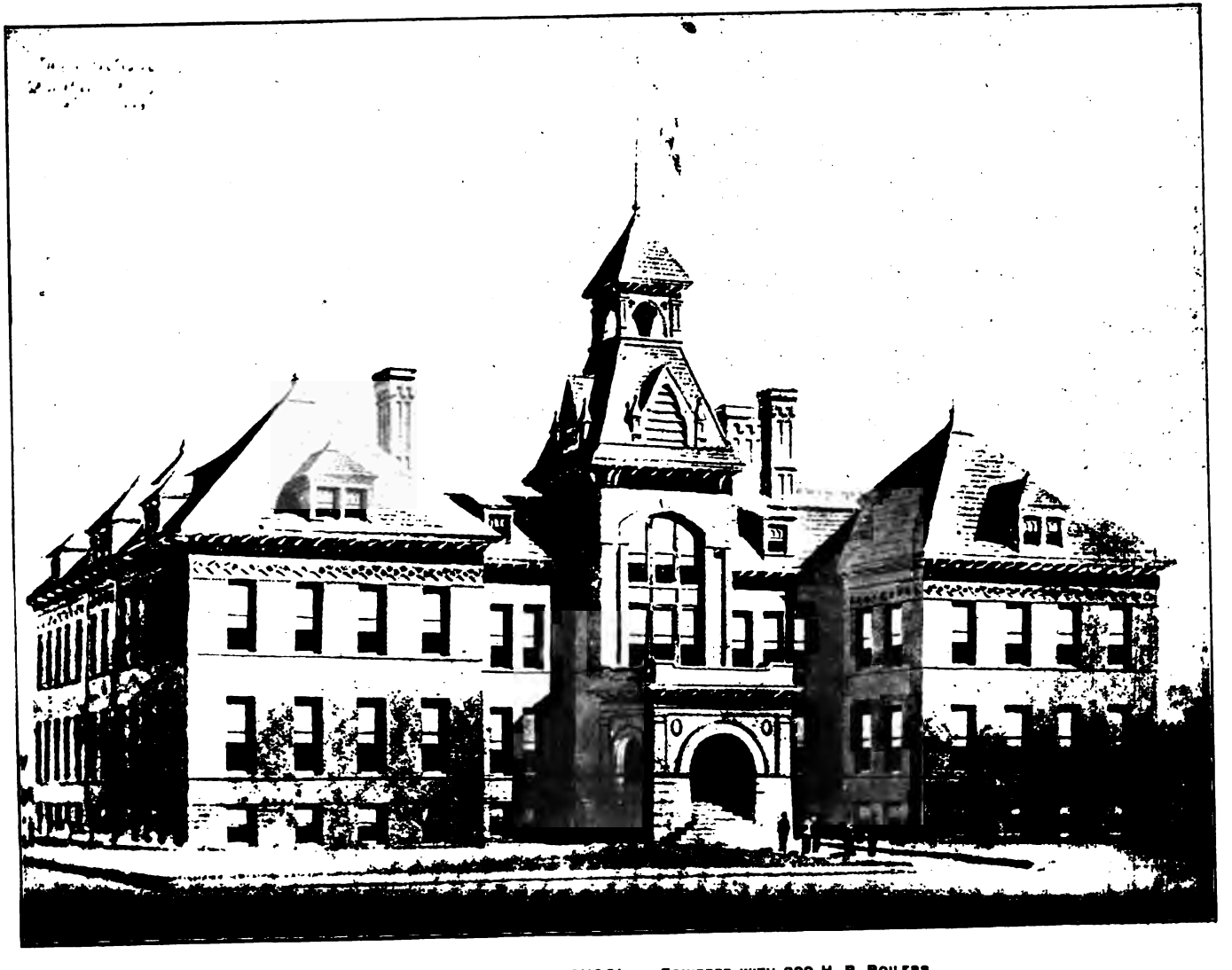

SAGINAW, EAST SIDE, HIGH SCHOOL. EQUIPPED WITH 200 H. P. BOILERS.

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RATE OF EVAPORATION UNDER ACTUAL CONDITIONS, per hour—

Number of pounds of water evaporated	7416.6
Number of pounds of water evaporated per sq. ft. of grate area	274.7
Number of pounds of water evaporated per sq. ft. of heating surface	4.265

RATE OF EVAPORATION FROM AND AT 212° FAHR., per hour—

Number of pounds of water evaporated	9055.67
Number of pounds of water evaporated per sq. ft. of grate area	335.4
Number of pounds of water evaporated per sq. ft. of heating surface	5.207
Horse-power developed, on the basis of 34.5 lbs. per horse-power	262.48
Rating of boiler, horse-power	150.
Excess above rating, horse-power	112.48
Percentage of excess above rating	75.0

CONCLUSIONS.

In comparing this test with others, regard must be had also to the heating power of the coal used. Professor Thurston (Manual of Steam Boilers, p. 488) cites a boiler trial in which the total heat of the coal was 14312 heat units and the percentage of ash was 6.7. If such a coal had been used in this test it would have evaporated 10.0 pounds of water per pound of coal, or 10.72 pounds of water per pound of combustible.

The capacity test showed remarkably good results. A comparison with the results obtained in a recent competitive test of a Babcock & Wilcox 416-horse-power boiler with two 200-horse-power Heine safety boilers will be instructive:

	Babcock & Wilcox.	Heine.	Wood's.
Pounds of water evaporated per square foot of heating surface per hour from and at 212° Fahr.	5.270	7.120	5.207
Percentage of moisture in steam	1.088	0.6195	0.29
Pounds of water per pound of combustible from and at 212° Fahr.	8.015	7.158	7.627
Pounds of coal burned per sq. ft. of grate area per hour	44.53	44.49	47.58
Average chimney draught, inches of water	1.016	1.111	.371

From this it appears that the Wood's Patent Water-Tube Boiler compares favorably with some of the best water-tube boilers on the market in regard to capacity. Particular attention should be called to the unusually good quality of steam when the boiler is forced to its greatest capacity, a matter of very great practical importance.

In conclusion, I desire to acknowledge the efficient aid of Mr. R. J. Allen, of the senior engineering class of the University of Michigan, in making the above tests.

Respectfully submitted,

FRANK C. WAGNER,
Asst. Prof. Mech. Eng., University of Michigan.

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TEST MADE BY MR. JAY M. WHITHAM, PHILADELPHIA, PA.,

of a 60-horse-power Wood's Patent Water-Tube Boiler, having the following dimensions: Tube cylinders, 48 inches diameter by 33½ inches long; 36 water tubes, 4½ inches diameter by 12 feet long; steam and water drum, 30 inches diameter by 18 feet long; necks, 14 inches diameter by 12 inches and 32 inches long; grate surface, 16 square feet; chimney, 24 inches diameter by 65 feet high; heating surface, 643 square feet; ratio of grate to heating surface, 40.2; square feet of heating surface to 1-horse-power, 10.7.

The test was started at 11 A. M., and, on account of inadequate water supply, was stopped at 3.30 P. M., thus continuing over a period of four-and-a-half hours. While this is too short a time to determine with precision the exact economic conditions of the boiler, yet, nevertheless, it is a very correct index of what it is capable of performing. The conditions as to temperature of water in boiler and at its height at the beginning of the test and at the end were identical, while the fire on the grate at the end of the test was nearly the same as at the start, with the exception that it was a trifle heavier and cleaner at the stop. It is unfortunate the test had to be stopped on account of low water in the well, for a longer test would have given better economic results. The test was run to determine the capacity of the boiler under natural draught, with run-of-mine "Clearfield" bituminous coal, and an inadequate chimney draught, $\frac{3}{16}$ inch in the water-column. The steam was used for power purposes. This boiler, with better draught, either natural or artificial, would develop much greater power, with as good an economic result. The moisture in the steam was determined from half-hourly readings of an improved wire-drawing calorimeter. The calorimeter correction was determined separately, under proper conditions. The coal was weighed, and the water measured in barrels, whose weight was ascertained, due regard being paid to temperature. The following results were noted:

COAL—	Pounds of wet coal used	1484.
	Percentage of moisture in coal	5.85
	Pounds of dry coal used	1400.
	Pounds of dry ash and refuse	105.
	Pounds of dry combustible	1295.
STEAM—	Mean pressure per gauge in pounds per square inch	72.8
	Percentage of moisture in steam	.51
WATER—	Pounds pumped into boiler at a mean temperature of 61° F	11185.
	Pounds of feed-water actually evaporated from 61° Fahr. at mean pressure	11016.
	Coef. of evaporation	1.192
	Pounds of water evaporated at and from 212° Fahr.	13131.
CHIMNEY—	Mean draught	$\frac{3}{16}$ water column
	Mean temperature	489° Fahr.

ECONOMIC RESULTS.

Water evaporated at and from 212° Fahr. per pound of wet coal	8.85
" " " " " " dry	9.38
" " " " " " combustible	10.14

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EXTERIOR VIEW DAYTON CITY WATER WORKS, DAYTON, OHIO.
EQUIPPED WITH FOUR WOOD WATER TUBE BOILERS, 150 LBS. PRESSURE.

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OTHER RESULTS.

Horse-power developed, on basis of A. S. M. E., or what is commonly called the Centennial rating	84.4
Percentage of excess power developed above rating	40.7
Pounds of wet coal per square foot of grate per hour	20.7
Pounds of wet coal per square foot of heating surface per hour	2.3
Actual square feet of heating surface per horse-power developed	7.54

REPORT ON THE QUALITY OF STEAM FURNISHED BY WOOD'S PATENT WATER-TUBE BOILERS IN CUMMER & DIGGINS' MILL AT CADILLAC, MICHIGAN.

The steam plant of the new mill of Cummer & Diggins' saw mill plant at Cadillac, Michigan, consists of two 200-horse-power Wood's Patent Water-Tube Boilers, made by Wickes Bros., Saginaw, Michigan. The boilers furnish steam to a 300-horse-power Nordberg engine, and also to two steam feeders and other machines about the mill.

The steam for the engine is taken from the tops of the front ends of the two boilers, and is conveyed to the engine by a seven-inch steam main, protected throughout its entire length by "magnesia" pipe covering. The distance from the center of the boilers to the engine is 53 feet 6 inches. The steam for all other purposes is taken from the rear ends of the two boilers. The fuel used is sawdust, burned in a specially constructed furnace.

Tests were made on the afternoon of November 29th to determine the quality of steam furnished by the boilers. The objects were: (a) to determine whether dry steam was being delivered to the engine; (b) to ascertain whether the boilers made dry steam; (c) to find out at which end of the boilers the steam was the dryer. Accordingly tests of the quality of steam were used, (a) on the main steam-pipe to engine, near the engine; (b) on the main steam-pipe to engine, near the boilers; (c) on the main steam-pipe to steam feeders, near the boilers. Tests (b) and (c) were made with a Barrus calorimeter, the steam being taken through perforated nipples extending about three inches into the sides of the steam-pipes, which were here horizontal. Test (a) was made with a Heisler calorimeter, taking steam through a perforated nipple, extending entirely across the seven-inch pipe, which was in this case vertical. Tests (a) and (b) were simultaneous.

Readings were taken as follows: For the Heisler calorimeter, the steam pressure in steam main by a Crosby test guage; the pressure in the body of the calorimeter immediately after expansion, by a mercury column; the temperature of the steam immediately after expansion. For the Barrus calorimeter, the temperatures of the steam before and after expansion. All of the above readings were taken every minute during the test. The pressure of the atmosphere was taken twice during the afternoon by means of an æneroid barometer, which was compared with a mercury barometer both before and after the test. The steam-guage used was compared with the standard gauge of the University of Michigan both before and after the test. The following results were obtained:

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TEST (A).

Duration of test	30 mins.
Average corrected steam pressure, (gauge) pounds per square inch	95.9
Greatest " " " " "	101.0
Least " " " " "	90.0
Average pressure in calorimeter, inches mercury	2.827
Greatest " " " "	3.0
Least " " " "	2.5
Average " " " " lbs. per square inch	1.38
Average temperature in calorimeter, degrees Fahr	259.05
Greatest " " "	263.
Least " " "	256.
Pressure of atmosphere, inches mercury	28.415
Pressure of atmosphere, pounds per square inch	13.95
Per cent. of moisture, average	1.51
" " greatest	1.75
" " least	1.17

TEST (B).

Duration of test	30 mins.
Average temperature before expansion, degrees Fahr	333.19
Greatest " " " "	336.
Least " " " "	329.
Average temperature after expansion, degrees Fahr	278.4
Greatest " " " "	280.5
Least " " " "	274.0
Per cent. of moisture, average	0.37
" " greatest	0.53
" " least	0.23

TEST (C).

Duration of test	10 mins.
Average temperature before expansion, degrees Fahr	340.55
Greatest " " " "	342.
Least " " " "	340.
Average temperature after expansion, degrees Fahr	288.07
Greatest " " " "	289.
Least " " " "	287.75
Per cent. of moisture, average	0.09
" " greatest	0.11
" " least	0.076

At times during tests (a) and (b) the engine pounded heavily. No more moisture was shown when the engine pounded than at other times.

From the foregoing tests it appears that these boilers are making unusually dry steam, and, furthermore, that the steam at the throttle of the engine is well within the limits of what is commonly recognized as commercially dry steam. It is also apparent that somewhat dryer steam can be obtained at the rear end of the boilers than at the front end. In either place, however, the steam is sufficiently dry for practical purposes.

Respectfully submitted,

FRANK C. WAGNER,
Asst. Prof. Mech. Eng., University of Michigan.

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F. & P. M. STEAMER, PLYING BETWEEN MILWAUKEE AND LUDINGTON.
BOILER SCOTCH MARINE. 11 1-2 FT. X 12 FT., PRESSURE 160 LBS

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REPORT OF TEST MADE ON A 160-HORSE-POWER WOOD WATER-TUBE BOILER, AT THE PLANT OF THE SAGINAW MILLING CO., SAGINAW, MICH., TO DETERMINE THE ECONOMIC EVAPORATION.

Date of test	December 6th, 1894.
Kind of Coal	Youghiogheny.
Duration of trial	9 hours.

Dimensions and Proportions.

Diameter of tube cylinders	72 inches.
Number of 4-inch tubes	96
Length of 4-inch tubes	18 feet.
Diameter of steam and water drum	50 inches.
Length " " "	23 feet.
Grate surface, 5 feet 7 inches wide, 5 feet long	28.5 sq. ft.
Water-heating surface	1824 sq. ft.
Ratio of heating surface to grate surface	64 to 1.

Average Pressures.

Steam pressure in boiler by gauge	110.5 lbs.
Atmospheric pressure	29.42 inches.
Force of draught in inches of water	.40

Average Temperatures.

Of external air	42 degrees.
Of fire-room	92 "
Of steam	344 "
Of escaping gases	427 "
Of feed-water	44 "

Fuel.

Total amount of coal consumed	5250 lbs.
Moisture in coal	2 per cent.
Dry coal consumed	5145 lbs.
Total refuse, dry, 239 pounds	4.6 per cent.
Total combustible	4906 lbs.

Results of Calorimetric Test.

Quality of steam	Dry.

Water.

Total weight of water pumped into boiler and apparently evaporated	47236 lbs.
Equivalent water evaporated into dry steam from and at 212° Fahr.	57391 lbs.

Evaporation.

Water actually evaporated per pound of dry coal from actual pressure and temperature	9.18 lbs.
Equivalent water evaporated per pound of dry coal from and at 212° Fahr.	11.154 lbs.
Equivalent water evaporated per pound of combustible from and at 212° Fahr	11.69 lbs.

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STEAMSHIP "EDWARD SMITH."
USING SCOTCH BOILER 13 FT. X 13 FT., ALLOWED 160 LBS. PRESSURE.

REPORT OF TEST MADE BY ARTHUR GIESLER, M. E., ON THE WOOD WATER TUBE BOILERS, PURCHASED BY THE CITY OF DAYTON, OHIO, FROM WICKES BROS., SAGINAW, E. S., MICH.

To the Trustees of Water Works of the City of Dayton, Ohio:

GENTLEMEN: I herewith submit a description report and results obtained from datas taken at the duty test of one of your new Wood's Water Tube Boilers.

The complete boiler consists of two water cylinders, seventy inches in diameter and twenty-one inches long, made of seven-sixteenth inch steel plates. These two cylinders are connected by ninety-two lap-welded, wrought iron tubes, four inches in diameter and seventeen feet long, placed in a staggered position and fastened into the heads by being expanded in the tube sheets.

The steam and water drum is fifty inches in diameter and twenty-two feet long, of open hearth flange steel, five-sixteenths inch thick. All longitudinal seams are double riveted.

One steam receiver (placed at right angles) twenty-two inches in diameter and fourteen feet long, serves for two boilers, from which the steam is taken and piped to pumps, or wherever used.

The boiler is suppported by steel beams and channels independent of brick work.

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Your specifications call for:

(*a*) Each boiler to be one hundred and fifty commercial horse power. By commercial horse power is to be understood the evaporation of thirty pounds of water per hour at a feed-water of one hundred degrees Fahrenheit, into steam of seventy pounds pressure.

(*b*) An evaporation of nine and one-half pounds of water from and at two hundred and twelve degrees Fahrenheit from one pound of Jackson coal.

In the following report statement (30) refers to clause (*a*) above, and statement (28) refers to clause (*b*) above, from which you will see the requirements of your specifications are more than satisfactorily met.

	REPORT OF TEST.	VALUES.	UNITS.
1	Date of Trial February 14, 1895.		
2	Duration of Trial, commencing at 8 A. M., ending at 10 P. M.	14	Hours.
3	Grate surface	23.92	Sq. ft.
4	Water heating surface	1696	Sq. ft.
5	Ratio of water heating surface to grate surface $\frac{1696}{23.92}=$	1 to 70.9	.....
6	Average steam pressure in boiler by gauge	94.55	Pounds.
7	Force of draft in inches of water	.525	Inches.
8	Average temperature of external air	25.68	Degrees.
9	Average temperature of steam	333.9	Degrees.
10	Average temperature of boiler room	78.55	Degrees.
11	Average temperature of escaping gases	396.7	Degrees.
12	Average temperature of feed water	44.41	Degrees.
13	Total amount of coal consumed, including one hundred pounds of wood at 40 per cent	7838	Pounds.
14	Moisture in coal by twenty-four hours' test	5	Per cent.
15	Dry Coal consumed 7838—5 per cent. =	7446.1	Pounds.
16	Total refuse	307	Pounds.
17	Total refuse in per cent. to coal $\frac{307}{7446.1}=$	4.1	Per cent.
18	Total combustible 7446.1—307=	7139.1	Pounds.
19	Dry coal consumed per hour $\frac{7446.1}{14}=$	531.8	Pounds.
20	Quality of steam	Dry	
21	Percentage of moisture in steam		
22	Number of degrees superheated		
23	Total weight of water pumped into boiler and evaporated	61751	Pounds.
24	Water actually evaporated	61751	Pounds.
25	Equivalent water evaporated into dry steam from and at 212 degrees $\frac{1215.40-44.41}{965.7}$ x 61751=	74842.2	Pounds.
26	Water actually evaporated per pound of dry coal from actual pressure and temperature $\frac{61751}{7446.1}=$	8.29	Pounds.
27	Equivalent water evaporated into dry steam from and at two hundred and twelve degrees per hour $\frac{74842.2}{14}=$	5345.8	Pounds.
28	Equivalent water evaporated per pound of dry coal from and at two hundred and twelve degrees $\frac{74842.2}{7446.1}=$	10.05	Pounds.
27	Equivalent water evaporated per pound of combustible from and at two hundred and twelve degrees $\frac{74842.2}{7139.1}=$	10.48	Pounds.
30	Horse power of boiler on basis of thirty pounds of water per hour, evaporated from one hundred degrees Fahrenheit into steam of seventy pounds gauge pressure $\frac{5345.8}{34.5}=$	154.9	H. Po'r.
31	Percentage of horse power at time of test above contract $\frac{154.9}{150}=$	3.2	Per cent.
32	Percentage of evaporation at time of test above contract $\frac{10.05}{9.5}=$	5.7	Per cent.

Respectfully submitted,

ARTHUR GIESLER, M. E.

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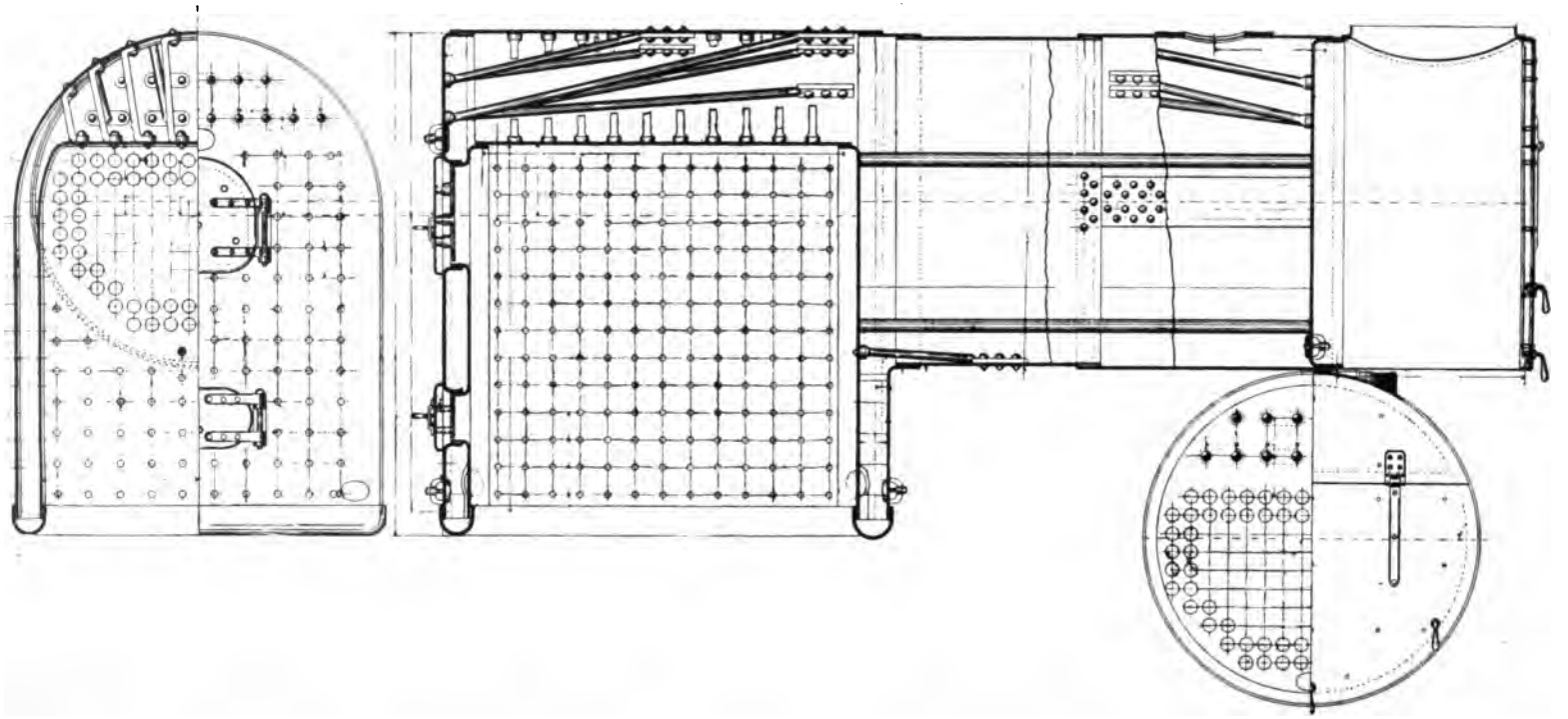

DRAWING.

Locomotive Marine Boiler.

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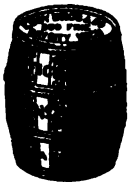
TESTIMONIAL LETTERS RECEIVED FROM USERS OF WOOD WATER TUBE BOILERS.

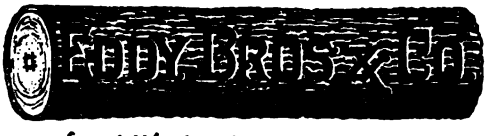
REPRODUCED IN FACSIMILE.

C. F. EDDY
J. F. EDDY.

OFFICE OF

G. A. EDDY.
SELWYN EDDY





Manufacturers of and Wholesale Dealers in Lumber, Lath and Salt.

Bay City, Mich., ~~June 5/96.~~ 189

Messrs. Wickes Bros.

Saginaw, E. S. Mich.

Gentlemen:-

We wish to state that we are much pleased with the battery of four " Wood's Water Tube Boilers " which you put into our saw mill this Spring, replacing seven boilers of the old style. also with the one boiler you put into the Eddy - Sheldon Co's. planing mill. We have been running them about two months now and find them easy steamers and economical fuel users and the workmanship of boilers and boiler settings is all that could be desired.

If we continue to get as good results from them in the future as we have so far, we shall feel well repaid for making the alteration.

Yours Respectfully

Eddy Bros & Co

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MORGAN & WRIGHT,
MANUFACTURERS OF RUBBER GOODS.
CHICAGO, ILL.
[illegible] TO [illegible] W. LAKE ST

Chicago, Ill., April 23, 1894.

Wicks Bros.,

East Saginaw, Mich.

Answering your inquiry as to how we like the Wood Water Tube Boiler which you furnished us, we would say we are not in the habit of giving testimonial letters and have not tried the boiler long enough as yet, to make our judgement of any practical value to the World at large.

But at the same time we can say that your contract with our firm has been executed in a workman-like and very satisfactory manner, and so far as we have gone with the boiler, running it night and day for the past two months, it has given perfect satisfaction. It is a splendid steaming boiler and at this writing, should we place an order for another boiler, we would select one of this type, both for its simplicity in construction making it a very easy boiler to clean. From our judgement it should be very durable and will be easy to repair should it get out of order at any time.

Hoping this will be satisfactory to you, we remain,

Very truly yours,

Morgan & Wright

MORGAN & WRIGHT,
MANUFACTURERS OF RUBBER GOODS.
CHICAGO, ILL.
[illegible] TO [illegible] W. LAKE ST.

Chicago, June 5, 1895.

Messrs. Wickes Brothers,
Gentlemen

If as you write your competitors are saying that your boilers were taken out of our plant on account of failure to do the work, we are more than glad to set the matter right so far as we are concerned by saying that, the boilers furnished by your firm on our three orders, are all at work, are running night and day and have given most excellent satisfaction.

The fact that we had some trouble with the first boiler must have given rise to the reports made, but in that case we all found after careful investigation that it was a matter of over work, and as soon as an additional boiler was placed in the plant we had no further trouble.

Since placing your boilers in our plant and it is worthy of mention that in doing this we destroyed a good plant which had cost us over $10,000,00 we have been free from complaint regarding smoke and have found the boilers which are equipped with Murphy furnaces, very economical.

The demands on our Steam plant are severe and your boilers have been worked day and night since they were placed in position.

Hoping this statement of our experience with your boilers will be of assistance to you and awaiting your further favors, we remain,

Yours very truly,

Morgan & Wright
By J. W. Morgan Pres't

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C. M. DAVIS, PRESIDENT
M. J. GILBERT, VICE-PRES. & GEN
ARNOLD SENTELL, SEC'Y & TREAS

NEW YORK BRANCH,
44 DEY STREET.

PHILADELPHIA BRANCH,
520 ARCH STREET

ST. LOUIS BRANCH,
1110-21 N. SIXTH ST

WICKES BROS.,
City, E.S.

SAGINAW, MICH May 27th, 1895.

Dear Sirs:

We wish to express our appreciation of the work your Wood, water-tube boilers are doing for us, and perhaps cannot do this better than by simply stating the facts.

We were using a battery of five tubular boilers and one 250 H.P., Babcock & Wilcox, water-tube boiler, all of which were fired to their full capacity. but we found it almost impossible to keep any of them clean, as they were fired constantly, day and night, although the Babcock & Wilcox was not quite so bad in this respect as the others. Your three boilers are nearly as clean now, after two years' constant use, as the day they were first fired, and we also find that we can clean one of them in less than one-fifth of the time required to clean the Babcock and Wilcox. While the latter was quite economical, we find the Wood boilers to be still more economical, as, at the end of six months' use we found a saving of $3,000.00 in fuel, most of which was due to the boilers.

When we put them in we were told by other manufacturers that the expansion and contraction of the Wood boilers were not properly provided for ~~in them~~, and that in a short time we would be troubled by leakage, but we are pleased to say that this prophecy has not yet been fulfilled and seems in no way likely to be.

Yours truly Saginaw Manufacturing Co.
M. J. Gilbert, Pr. & Manager

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ESTABLISHED 1872

CAPITAL STOCK $300,000.00

(Contd.)

June 8th, 1895

Wickes Bros.,

Saginaw, Mich.

Gentlemen:--

In reply to yours of the 3rd inst: We are pleased to say that the 2 - 200 H.P.Wood Water Tube Boilers placed for us, about two years since, have been in constant use, night and day and have proved thus far, entirely satisfactory.

If we were in need of additional steam power, we would certainly place more boilers of the same kind.

They are easy of access to cleaning. Require cleaning less often than any other boilers we know of. We clean once in 60 days, owing to position of blow off, not required oftener.

Thus far have not cost us one dollar for repairs and they are apparently in as good condition today as when erected.

Very truly yours,

Grand Rapids Chair Co.,

Grand Rapids, Michigan.

E. C. HARGRAVE & CO
MANUFACTURERS OF
SULPHITE FIBRE, LUMBER,
AND BOX SHOOKS.

MILLS
BAY CITY, MICH. HINCKLEY, N. Y.

DAILY CAPACITY.
50 tons Sulphite Fibre.
300,000 feet Lumber.
40,000 feet Box Shooks

Hinckley, N.Y. June 8, 1895.

Messrs Wickes Bros.,

Saginaw, E. S. Mich.

Gentlemen:- We have your favor of the 3rd inst asking us in regard to the Water Tube Boilers which you put in for us at this place. We can only say that they are working very satisfactorily and if we were going to put in new Boilers we would put in the same kind.

Yours respectfully,

E. C. HARGRAVE & CO.,
Per W.B. Ostrander.

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OFFICE AND YARD AT WEST END OF GENESEE AVENUE BRIDGE

C. K. EDDY & SONS.

CHAS. K. EDDY Pres.
WALTER S. EDDY V. Pres.
ARTHUR D. EDDY Secy.
KIRKE EDDY Treas.

MANUFACTURERS AND DEALERS IN ASSORTED LUMBER

AT WHOLESALE

BY CARGO OR CARLOAD

SAGINAW, MICH. June 4th '95.

Wickes Brothers,

Saginaw, E.S., Mich.

Gentlemen,-

In sawing Hemlock, Hardwood or Pine Logs, no matter what kind of weather prevailed since we started our Mill nearly one year ago, with our new steam plant of four Water Tube Boilers furnished by yourselves, we have always had steam in abundance for twenty-four hours, without the use of other fuel than the sawdust and refuse from our Mill, not using any four foot slabs. This you will see is a remarkable change, when with our old plant, which was by no means old styled, we had to use when sawing either Hemlock or Hardwood Logs, twenty-five to fifty cords of dry slabs during the twenty-four hours, and in sawing Pine we had to use more or less of dry slabs, and never, with possibly few exceptions, did we ever go to the Mill and return with feelings other than a desire to some day have a steam plant that did not worry the life out of us at the great expense to keep it going, and never to have steam enough. While we grumbled a good deal at the time of putting the plant in, at the amount of money the change was going to cost, we now feel that it was well expended and will not be long in coming back. Another thing that we consider a matter of great importance is the security of these boilers, as until we had this plant, we were never without the fear of a boiler explosion.

Very respectfully,

C. K. Eddy & Sons,

By W. S. Eddy V.P.

P.S.-Our requirements for steam are just as great, the fourteen hours we do not operate our saw-mill, as when we do, in the manufacture of salt, which is carried on by exhaust steam from our mill engines when the mill is running, and by live steam the balance of the time, and it is this portion of our business that demands the greatest economy in fuel, and only by being able to use the rubbish for fuel, that we have heretofore carted away at great expense, would we feel justified in making salt, except during the ten hours that our saw-mill is in actual operation.

C.K.E.& S's.

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Ann Arbor, May 14, 1892.

Messrs Wickes Brothers,

Saginaw East Side,

Michigan.

Gentlemen:-

Please accept my apology for delaying my reply of yours of April 16 also of the 6th inst. I have been ill for several weeks and since getting on my feet have had to care for my class work in College. Correspondence in consequence has greatly suffered. I will endeavor to advise shortly at the earliest date which will be possible for me to come to Saginaw to finish up the boiler test recently begun by Prof. Wagner. I greatly regret the delay which cannot have inconvenienced you more than myself. I congratulate you upon the results of the tests made by Prof. Wagner. I trust that the other experiments will show even better results.

I beg to remain,

Yours very truly,

W. E. Cooley.

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Wellington W. Cummer.

Cadillac, Mich. Apr. 28, 1893.

Wm. S. Hovey,

Grand Rapids, Mich.

Dear Sir:- Your letter of the 26th duly received. We have given the Woods boilers a pretty thorough test and find them to be all that Wickes Bros. have claimed for them. They make steam very rapidly, are very economical, and have given us no trouble whatever.

Where fuel is an item of cost to be considered; I think these boilers rank among the first. They are made very substantial in all their parts.

At one mill we have five tubular boilers and we have burnt on an average of about four cords of wood per day, together with the sawdust we get from the saws, which produce as much dust as is made where the Woods boilers are, and in the last mill referred to, we burn no slabs, except on Monday mornings to start up.

I use the same boilers in my Electric Light and Water plant with equal satisfaction.

If you think of any questions you would like to ask relative to the workings of the boilers, I will take pleasure in answering them.

Very truly yours,

W W Cummer

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Grand Rapids, Mich. Aug. 15, 1893.

Messrs. Wickes Bros.

East Saginaw, Mich.

Gentlemen:-

We have yours of the 14th. inquiring how we are satisfied with the Wood boiler, which you placed in our works lately. Will say that we are very much pleased with same. We have to clean this boiler only once in five years, where formerly we cleaned the common tubular boiler once every two weeks and we find the boiler in very fine condition even then. We are satisfied that it will save a large percentage of fuel above the ordinary tubular boiler pay for itself in a short time on that account. We are also satisfied that of all the water tube boilers, this is the most simple, durable and easy to clean also that it can be repaired with less expense. We are also satisfied that the boiler is made in first class shape and can recommend same to anybody's careful observation as of first class workmanship. If we were to put in any more boilers, we are convinced that we would use nothing but the Wood boiler.

If this is any special use to you and will do you any good we are very glad.

Yours respectfully,

NEW ENGLAND FURNITURE CO

H. M. Amsden Sec & Treas

Mgr

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SAGINAW MILLING CO.

Saginaw, Mich. May 29, 1895.

Wickes Bros.,

City, E.S.

Gentlemen:-

We have now had one of your 175 H. P. Woods Water Tube Boilers in constant use night and day for six months. Its success as an economical steam generator is demonstrated to us beyond a doubt. Our engine indicates that fully 175 H. P. is being used and we run with dampers closed, using 8 cord pine slabs on a 24 hour run at a cost of 90¢ per cord delivered at our mill.

Since starting our mill we have not lost one minutes time through any cause from the boiler. Our Engineer takes care of the Corliss engine and Electric Dynamo and does his own firing with ease.

Judging from our experience with boilers, would say that you have, beyond a question, the best and most economical boiler of the day.

Yours truly,

SAGINAW MILLING CO.,
Henry W. Carr GEN. MGR.

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The Ireland & Matthews Manufacturing Company,
Stove Trimmings and Plumbers' Supplies,
Sheet Metal Goods.

M. S. Mills, President.
C. H. Matthews, Vice-President
F. T. Dunham, Treasurer.
E. Blake, Secretary.
D. M. Ireland, Manager

Office and Works: Cor Wight St. and Mt. Elliott Ave.

Detroit, Mich. June 13 1895

Messrs Wicher Bros
East Saginaw Mich

Gentlemen

Replying to your favor regarding the Wood Water Tube Boiler we would state that we are very much pleased with the boiler. We have now had it in constant use for six months and have found it a rapid steamer and very economical in fuel and is in every way thoroughly satisfactory

Respectfully,
Ireland & Matthews Mfg Co

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Telephone No. 385.

OFFICE OF

National Brewing Company.

HUBINGER, WEBER & CO

Bottling Works in Connection

Saginaw, E. S., Mich., Nov 29th 1895

MESSRS. WICKES BROTHERS,

SAGINAW, MICH.

GENTLEMEN:

Early last year we placed in our brewery in this city one of your 100 H.P. Wood's Patent Water Tube Boilers, taking out a good tubular boiler and replacing it with yours to get economy and safety in our boiler plant

We are very much pleased with your boiler as it has given us excellent results. It is considerably more economical than the tubular boiler, very much easier to clean, and is giving us perfect satisfaction.

Wishing you success with your new boiler, we remain,

Yours truly,

National Brewing Co
by Wm L Weber

Digitized by Google

Revenue Marine
Iowa Iron Works
Port of Dubuque, Iowa.
Sept. 10th 1894

Wicks & Bro's
East Saginaw
Mich.-

Gents:-

Will you please give me the exact weight of the Rev. Cutter Windom's boiler as it left your shop?

Permit me to congratulate you on the beautiful work done on the above. Every boiler maker in this city has seen it, and many others from adjacent towns and cities, all have only words of praise for the mechanical skill and workmanship shown on it.

Respectfully yours
Charles H. Ball
Chief Engineer R.C.S.
Inspector of Machinery
Iowa Iron Works

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Office of the

Masonic Executive Board.

E.S.
Saginaw, Mich., May 28, 1895. 189

Messrs. Wickes Bros.,

Saginaw, E.S., Mich.,

Gentlemen:

The Wood Patent Water Tube Boiler that was bought from you in the Fall of 1892 to heat the Masonic Temple has given excellent satisfaction in every particular. It is economical in the consumption of fuel. and easy to clean and repair. Some time ago. through the carelessness of some workmen in leaving the blow-off cock open whereby all the water was permitted to run out of the boiler, we had the misfortune to burn the tubes, but beyond the injury to the tubes themselves, there was no damage done whatever.

We can cheerfully recommend it to anyone requiring the use of such a boiler, and you are at liberty to refer any enquirers to us.

Yours very truly,

W. J. Bartow
Chmn

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Michigan Asylum for the Insane,

Kalamazoo, Mich. June 8, 1895.

Messrs. Wickes Bros.,

Saginaw, Mich.

Gentlemen,-

It gives me great pleasure to commend the Wood Watertube Boilers built by you for the Michigan Asylum in 1893. The twelve hundred horse powers are set in four batteries of three hundred ~~horse~~ horse powers, two boilers in each battery. These boilers have been in regular service now for more than a year without any expenditure for repairs that was caused from any defects in the boilers. One tube has been replaced, having accidentally been made defective, but no other repairs or replacements have been required.

They are ready steamers and the quality of the steam is most excellent, as shown by Calorimeter tests We have effected a considerable saving in coal by the use of these new boilers over the old horizontal tubular ones formerly in use, and at the same time have done a much larger amount of work.

These boilers were selected for the Asylum work after a most thorough inquiry into the merits of many other watertube boilers as presented by your competitors. We have no reason to regret our choice and simply say that we are thoroughly pleased with them in every particular.

I am very truly yours,

J. D. Turnbull. Chief Engineer.

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THE CUMMER CO.
MANUFACTURERS OF KILN DRIED
North Carolina Pine
LUMBER

W. W. Cummer, Pres.
J. Cummer, Vice Pres.
E. C. Fosburgh, Sec & Mgr.
H. J. Hollister, Treas.

Norfolk, Va. June 6th., '95.

Messrs. Wickes Bros.

Saginaw, Michigan.

Dear Sirs:-

We are just in receipt of your favor of the 3rd. inst., also yours of May 25th. came duly to hand, and should have been answered more promptly but for the fact that the writer has been absent from home during the past ten days, and has just returned.

In regard to the water-tube boiler which you furnished for our new planing mill last Winter. We take great pleasure in saying that it has given us the most satisfactory results so far, and we have no hesitation in saying that we would not be without this boiler for a good deal more than the price which you charged us for it, as we consider it by long odds the most economical and satisfactory boiler that we have ever used. We remain,

Yours very truly,-

THE CUMMER CO.

E. C. Fosburgh

Sec'y. & Mgr.

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June 4, 1895.

Messrs. Wickes Bros.,

Saginaw, Mich.

Gentlemen:- It give us pleasure to state that the Wood's Water Tube Boiler placed in our plant in connection with our new planing mill, is giving excellent satisfaction. We believe that in the saving of fuel, the additional cost of this boiler will soon be made up; and we would cheerfully recommend this type of boiler to other parties interested in planing mill property, to whom the saving of shavings is an object.

Yours truly,

The Eddy-Sheldon Co.

Dic. F. E. P.

Office of the Superintendent

Calumet Electric Street Railway Co.

Burnside Crossing, Cook County,

Chicago, August 9th/95.

A. M. Castle. Esq.,

Manager Wickes Bros.,

Chicago, Ill.

Dear Sir:

This company takes pleasure in expressing to you the satisfaction which it has gained in the use of your five 200 H.P. boilers at our Burnside plant; they are giving very good service. We wish also to thank you and the officers of your company for the courteous treatment received from that quarter.

Yours very truly.

Calumet Electric St. Ry. Co..

Arthur J. Whipple. Secy.

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Office of the Gen'l Superintendent,

Calumet Electric Street Railway Co.

Burnside Crossing, Cook County,

John Oliphant Jr.
F. [redacted],
GEN'L SUPT.

Chicago, Sept. 7th, 1894.

Mess. Wickes Bros.,

Saginaw, Mich.

Gentlemen:--

In regard to inquiry of your Mr. A. M. Castle as to the Wood's Patent Water Tube Safety Boilers, of which we have five in use, of 200 H.P. each, carrying a steam pressure of 120 to 130 lbs. per sq. inch, I would say that after continued use of fifteen (15) months, we have found them very satisfactory especially as regards repairs and renewals of parts. We have not as yet lost any tubes in these boilers, and in fact have had to renew nothing.

Wehave little trouble in keeping them clean, and they have given general satisfaction. No accurate tests as to evaporation have been made, but from rough tests we think we get good evaxporation from these boilers.

Yours truly,

John Oliphant Jr

General Supt.

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Store, Office and U.S. Bonded Ware House.

Bass & Co's Pale Ale and Apollinaris Water

Nov 26 1893

Miss Wickes Boiler
Saginaw Mich
Gentlemen

We wish to express to you our entire satisfaction with the Water Tube Boiler purchased of you

We think that we have the best and most economical Boiler in use in our City for it requires very little attention & we heat our seven story block with about one half ton of Soft Coal per day what more can we ask. you are at liberty to refer any prospective customers to us

Yours respectfully

Kortlander & Murphy

Nov 26, 93

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Store, Office and U.S. Bonded Ware House.

Bass & Co's Pale Ale and Apollinaris Water

May 25, 1895.

MESSRS. WICKES BROS.,

SAGINAW.

GENTLEMEN:

In reference to your Wood's Patent Water Tube Boiler which has been in use in our large store and office building in this city for the past three years, we take pleasure in saying that this boiler has proven itself all that it was recommended to be. It is economical and easy to clean, and we have not laid out a dollar for repairs since the same was put in use. We are highly pleased with this boiler and can recommend it to anyone who is in want of a first-class, safe and economical boiler.

Yours truly,

Kortlander Murphy Co

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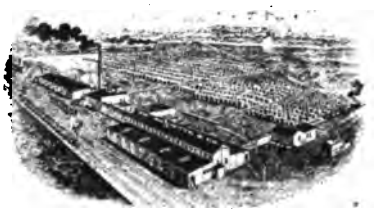


FACTORY & YARD COVERING 32 ACRES AT SAGINAW MICH

WM. SCHUETTE & CO.

WHOLESALE **Assorted Lumber**

MOULDINGS

PLAIN & FANCY SHINGLES A SPECIALTY

SPECIAL SIZES CUT TO ORDER

WILLIAM SCHUETTE SAGINAW
CHAS. LEEPER CLARION PA
A. C. COPPERMAN PITTSBURGH
H. H. SCHUETTE

Saginaw, Mich June----1----95

Wickes Bro

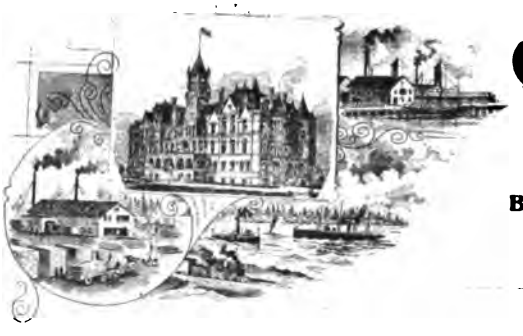
City, E. S.

Gentlemen :--

We have now had the two 150 horse power Wood Water Tube Boilers you furnished us, in constant use for six months, and can state that we are highly pleased with them. They come up fully to all that we expected and that you said they would do. They are quick steamers, economical in consuming fuel, and are satisfactory to us in every way.

Yours truly,

Wm Schuette & Co



CITY OF SAGINAW, MICHIGAN.

Board of Water Commissioners' Office.

May 24th, 1895.

MESSRS. WICKES BROS.,

CITY.

GENTLEMEN:

Nearly two years ago we placed in our West Side Pumping Station three of your 125 H.P. Wood's Patent Water Tube Boilers, which were selected by our Water Board from the various types of water tube boilers manufactured, and we can assure you that these boilers have given us excellent results. They have been in constant use night and day since they were put in, and have not had any leaks or repairs during the time they have been in operation.

Yours truly,

F S Keller Secy

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J. L. LITTLEFIELD

MANUFACTURER OF

PINE, HEMLOCK AND HARDWOOD LUMBER,

LATH AND SHINGLES.

Wickes Bros
Saginaw E.S. Mich

Farwell, Mich., 189

Dear Sirs

The 150 H.P. Woods Patent-Water Tube Boiler that I bought of you, and placed in my Band Saw mill, last fall, has proven highly satisfactory in every respect; I run Band Saw, Shot Gun Steam Feed. Edger, Trimmer, Lath mill, and planer, and can hold the pressure right up to 90 to 100 lbs. using very little fuel ~~[illegible]~~ from the Band Saw dust and Edger dust;

I consider this one of the most Economical Boilers made. With it; I can save about one third to the cost of my mill, and save in fuel and labor several dollars per day

Yours Truly
J. L. Littlefield

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T. B. Snow, President
L. T. Quand, V. President

J. M. Nash, Secy and Treas
W. J. Hart, Gen Manager.

Saginaw Union Street R'y.

Saginaw, E. S., Mich., May 24, 1895.

Messrs. Wickes Brothers,

City.

Gentlemen:

We wish to express our entire satisfaction with the three 150 H.P. Wood's Patent Water Tube Boilers placed in our new power house at Saginaw, Mich. The material, workmanship and setting of these boilers are first-class in every respect, and we take pleasure in recommending them. They are easy steamers, easy to clean and take care of, and exceptionally economical in fuel.

Hoping that you will meet with success with your new boiler, we remain

Yours truly,

Union St. Ry. Co.
W. J. Hart
Genl. Manager

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SIBLEY & BEARINGER.
—DEALERS IN—
PINE, FARMING & MINERAL LANDS,
LUMBER, LATH AND SHINGLES.

HIRAM W. SIBLEY, 21 Exchange St., Rochester, N. Y
ISAAC BEARINGER, Saginaw, East Side, Mich

Saginaw, (E. S.,) Mich., May 23, 1895.

Messrs. Wickes Bros.,

Saginaw, E. S., Mich.

Gentlemen:

I have had in use in my building in this city for the past three years, two of your 75 H.P. Wood's Patent Water Tube Boilers, furnishing steam for this building and my other buildings adjoining. also running elevators and pumps for use in said building.

The boilers have given me perfect satisfaction, I have not laid out a dollar on them for repairs in all the time they have been in use, summer and winter. and I can recommend them to anyone in want of boilers as a safe and economical boiler for almost any use.

Yours very truly,

Isaac Bearinger

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Saginaw April 5-1895

Messrs Hicks Bro's.
Saginaw Mich.

Gentlemen:

In reply to your inquiry as to the work done by the Water Tube Boilers placed by you in the West-Side Pumping Station, I would say the following figures show the comparative amt. of fuel burned and water pumped by the Tubular and Water Tube boilers

Tubular boiler - size of shell 5 ft. x 16 ft. - 64 - 3 3/4 in tubes. March 1894
Coal burned 242 527 lbs. Coal per day 7823 lbs
Water pumped 62. 158. 426 gals. Water " 2 005 110 g.
Amt. of water pumped per lb of coal 255 gals

125 H.P. Water Tube Boiler.

March 1895
Water pumped 64285606 gals.
Coal burned 174835 lbs.
Amt. of Coal per day 5639 lbs
Amt. of water " " 2730407 gals
Amt. of water per lb of coal 367 gals

Robert. D. Stewart.
Engineer
West Side Pumping Station

Digitized by Google

Grand Rapids, Mich., May 29, 1895

Wicks Brothers,
East Saginaw Mich

Dear Sirs

In reply to yours of the 25th in reference to the boiler we are using & which we got from you Will say it is just two years since we began using the boiler & can only state we find it is the only boiler made, that is perfection, if such a thing is a possibility. We can not speak too highly of your boiler & you are free to refer to us at any time you see fit. As a steam maker and an economizer of fuel it is unapproachable

Yours truly Empire Straw Work.
W G Kiesel Secy

—OFFICE OF—

G ★ FLOURING MILLS.

MANUFACTURERS OF AND DEALERS IN

FLOUR, FEED, CORN, OATS, RYE, MEAL, ETC.

OFFICE AND MILL. 215 NORTH FRANKLIN STREET

Wm. Callam & Son,
Proprietors.

Saginaw, E. S., Mich., June 5 189 5

Messrs Wicks Bros

Dear Sirs

In reply to yours 2nd inst Can use the following testimonial

June 4 - 95

Your water tube boiler has been in operation for weeks this year in our flouring mill and sufficient to say we consider it we use the cheapest machine on the plant Carrying 50 # steam - 24 Hours run and manufacturing 125 bbls flour - require 2 cords slabs @ 85c to furnish power

Very truly yours
W Callam Son
Propr "Star" Flouring Mills -

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THE WESTERN UNION TELEGRAPH COMPANY.
21,000 OFFICES IN AMERICA. CABLE SERVICE TO ALL THE WORLD.

This Company TRANSMITS and DELIVERS messages only on conditions limiting its liability, which have been assented to by the sender of the following message. Errors can be guarded against only by repeating a message back to the sending station for comparison, and the Company will not hold itself liable for errors or delays in transmission or delivery of Unrepeated Messages, beyond the amount of tolls paid thereon, nor in any case where the claim is not presented in writing within sixty days after the message is filed with the Company for transmission.
This is an UNREPEATED MESSAGE, and is delivered by request of the sender, under the conditions named above.
THOS. T. ECKERT, General Manager. NORVIN GREEN, President.

Number 7 | Sent by 3 P R | Rec'd by 6 Co | Check 887

RECEIVED at 100 Griswold St., DETROIT, MICH. 9:15a M. Standard Time. Sept 21st 1894

Dated Grand Rapids Mich 21

To Detroit Chamber of Commerce

Wicks Bros Boilers perfectly satisfactory

G R Chair Co

THE WESTERN UNION TELEGRAPH COMPANY.

This Company TRANSMITS and DELIVERS messages only on conditions limiting its liability, which have been assented to by the sender of the following message. Errors can be guarded against only by repeating a message back to the sending station for comparison, and the Company will not hold itself liable for errors or delays in transmission or delivery of Unrepeated Messages, beyond the amount of tolls paid thereon, nor in any case where the claim is not presented in writing within sixty days after the message is filed with the Company for transmission.
This is an UNREPEATED MESSAGE, and is delivered by request of the sender, under the conditions named above.
THOS. T. ECKERT, General Manager. NORVIN GREEN, President.

Number 17 | Sent by 3 P R | Rec'd by 6 Co | Check 444

RECEIVED at 100 Griswold St., DETROIT, MICH. 2:02pm M. Standard Time. Sept 20 1894

Dated Saginaw West Side Mich 20

To Detroit Chamber Commerce

have used wood boilers one year, we cannot speak too highly of them. they reach their rating easily, can obtain better and in one fourth the time we could the stock of same capacity

Saginaw Mfg Co

THE WESTERN UNION TELEGRAPH COMPANY.
21,000 OFFICES IN AMERICA. CABLE SERVICE TO ALL THE WORLD.

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This is an UNREPEATED MESSAGE, and is delivered by request of the sender, under the conditions named above.
THOS. T. ECKERT, General Manager. NORVIN GREEN, President.

Number 1054 | Sent by 7 A R | Rec'd by 36 Co | Check 9 Ex 542

RECEIVED at 100 Griswold St., DETROIT, MICH. 2:42pm M. Standard Time. Sept 20th 1894

Dated Grand Rapids Mich 20

To Detroit Chamber of Commerce.

are very much pleased with the wood boiler would not think of buying any other. very economical in fuel easy to clean. will make an recommend very highly must be set good

New England Furniture Co
H M Amsden mgr

THE WESTERN UNION TELEGRAPH COMPANY.
21,000 OFFICES IN AMERICA. CABLE SERVICE TO ALL THE WORLD.

This Company TRANSMITS and DELIVERS messages only on conditions limiting its liability, which have been assented to by the sender of the following message. Errors can be guarded against only by repeating a message back to the sending station for comparison, and the Company will not hold itself liable for errors or delays in transmission or delivery of Unrepeated Messages, beyond the amount of tolls paid thereon, nor in any case where the claim is not presented in writing within sixty days after the message is filed with the Company for transmission.
This is an UNREPEATED MESSAGE, and is delivered by request of the sender, under the conditions named above.
THOS. T. ECKERT, General Manager. NORVIN GREEN, President.

Number 16 | Sent by 7 P R | Rec'd by 20 Co | Check 387

RECEIVED at 100 Griswold St., DETROIT, MICH. 12:40p M. Standard Time. Sept 20 1897

Dated Kalamazoo Mich 20

To Det Chamber of commerce

wood boiler built for us by Wickes Bros very satisfactory satisfy fully executed our recommend boiler & the firm

Upton & Edwards

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THE WESTERN UNION TELEGRAPH COMPANY.

RECEIVED at 100 Griswold St., DETROIT, MICH.

Ann Arbor Mich 20

Detroit Chamber of Commerce

Prof Cooley authorizes me to wire you that he expresses himself well pleased with Kalamazoo Dant and that Wickes Bros do fine work. E. D. Reid

THE WESTERN UNION TELEGRAPH COMPANY.

RECEIVED at 100 Griswold St., DETROIT, MICH.

Ann Arbor Mich 20 Sept.

Detroit Chamber of Commerce

Prof Cooley away have wired your message to him

E. D. Reid

THE WESTERN UNION TELEGRAPH COMPANY.

RECEIVED at 100 Griswold St., DETROIT, MICH.

Ann Arbor Mich 20 Sept 20 1884

Detroit Chamber of Commerce

Wicks Boiler bears best of reputation so far as we know we get more and better steam power and less fuel we believe wicks boiler has many advantages over other water tube boilers

Ch Eddy & Son

TELEGRAM

To Dr Ay Do 10 Cloud Mich Sept 20

Cadillac Mich Sept 20

Detroit Chamber of Commerce

Detroit Mich

Will please class builders.

are first Cummer and Diggins

CHAS W ASBURY, PRESIDENT C FRANK BARRETT VICE PRESIDENT HENRY A. TRUITT, SEC., TREAS. & MANAGER.

Cheltenham
Electric Light, Heat & Power
Company,

Oak Lane, Station A.
Philadelphia,

Aug 29th. 1893

Mess Wickes Brothers.
Gentlemen
Replying to your favor of 24th inst., will state we have two of the Wood Boilers referred to.
They have been in use every night from dusk until dawn for nearly 3 years, and have proven very satisfactory.
They are inspected regularly and have discovered very little scale.
They are kept clean without trouble and generate steam with the minimum consumption of coal.
Our Water is not detrimental to Iron.

— Yours truly Henry A. Truitt
Manager

Johnstown · Electric · Light · Company

OFFICE AND STATION FEND ALLEY

Johnstown, Pa., AUG 28 1893 1893

Wickes Bros.,
East Saginaw
Mich

Gentlemen:—
In reply to your favor of the 24th inst. regarding the Wood boiler which we are using, we would say that we have been using the boiler nearly two years. and find that it is a well put up boiler, and that it has given us no trouble whatever during this time.
We are not troubled anywhere with scale and so cannot make any definite statement except that we think that owing to the slanting of the tubes that all sediment has a tendency to go into the drum at the rear and out through the blow off.
We experience no difficulty in keeping the boiler clean. Hoping that we have fully answered your letter — we remain
Yours truly
per J. W. Reeves Supt.

Digitized by Google

FALLS OF SCHUYLKILL

BLANKET MILL.

JOHN DOBSON.

Philadelphia, August 28th 1893

Mess Wickes Bros
E Saginaw
Gent.n

In reply to your favor of 24th inst have to say That I have the Wood Water Tube Boilers in use in my mills and same have always given me entire satisfaction and I find them to be as represented in all respects Also have no difficulty in keeping the tubes free from scale have had same in use for three years.

Yours truly
John Dobson
Per Francis

PIG IRON, PUDDLE BARS,
STEEL INGOTS AND SLABS,
BOILER, BRIDGE AND SHIP PLATES,
CUT NAILS AND SPIKES

OFFICE OF
Successors of POTTSTOWN IRON CO
Pottstown, Pa.,

Aug. 29th., 1893.

Messrs. Wicks Bros.,

East Saginaw, Mich.

Gentlemen:--

Replying to your favor of the 24th inst. in relation to the Water Tube Boiler furnished us by John Wood, Jr., beg to say that we have had it in use some five years and have had no trouble with it.

Trusting this will be satisfactory, we are,

Yours truly,

Dictated J. T. H.

POTTSTOWN IRON CO.

The Duncannon Iron Company.
Manufacturers of
BAR IRON, NAILS AND PIG IRON.

Duncannon, Perry Co. Pa. Aug 28th 1893

Wm J. Wickes
Dear Sir

Yours of 24th inst, is received In reply we have five Wood Water Tube Boilers in use for three and a half years and they have given entire satisfaction, and if we were in want of more boilers would take the Wood

Yours truly
Duncannon Iron Co

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To Trustees Water Works Board, City of Dayton, Ohio:

GENTLEMEN:

Your Committee to whom was referred the question of deciding as to the merits of Steam Boilers to be used at the Pumping Station, respectfully report that they have carefully considered the subject from all standpoints and unanimously decide to recommend for purchase the ''Wood Boiler,'' proposal for which was presented from Wickes Brothers, Saginaw, Michigan.

The reasons that lead to this decision are briefly summed up as follows:

The mechanical construction of the different types of boilers, estimates for which were opened by you, we carefully investigated from a mechanical standpoint, aided by drawings, and we finally concluded on a choice of two styles, namely, the ''Heine'' and ''Wood,'' but as there were none of the latter in the immediate vicinity, with your consent we took a trip to Grand Rapids, Michigan, visiting the works of the New England Furniture Co., the Grand Rapids Chair Co., and the Royston Straw Works, all of whom have the Wood Boilers in their respective factories, and who unanimously recommended the same to us, ''for simplicity of construction, ease in cleaning, evaporative efficiency and reduced cost of repairing when same is necessary,'' but so far in all their experience, repairs have not been needed. These reports, together with our own observation and mechanical experience, decide us to report as above.

Yours respectfully,

J. C. MERKLE,
Chief Eng. Dayton Water Works.

ARTHUR GIESLER,
Supt. Stillwell-Bierce & Smith Vaile Co.

(Copy)

GEO. MARSHALL,
Genl. Mgr. Dayton Boiler Works.

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PARTIAL LIST OF USERS OF WICKES BROS.' BOILERS.

Alpena Sulphite Fiber Co., Alpena, Mich.
Albert Pack, Alpena Mich.
Alma Roller Mills, Alma, Mich.
Big Creek Lumber Co, Alexandria, La.
Western Plaster Works, Alabaster, Mich.
N. H. Weston, Armada, Mich.
Penoyar Bros., Au Sable, Mich.
S. McLean, Bay City, Mich.
Boutell & Smith, " "
James Reid & Son, " "
Dolsen & Chapin, " "
E. C. Hargrave, " "
Bousfield & Co., " "
The Keystone Constrc'n Co., " "
R. Armstrong, " "
M. Garland, " "
Jas. Davidson, " "
Bay Co. Electric Light Co., " "
F. W. Wheeler & Co., " "
Eddy-Sheldon Co., " "
Eddy Bros. & Co., " "
Smalley & Woodworth, " "
Penokee Lumber Co., Bad River, Wis.
B. F. Sturtevant Co., Boston, Mass.
Buffalo Forge Co., Buffalo, N. Y.
Pratt & Letchworth, Buffalo, N. Y.
Thomas Tindle & Co., Bellaire, Mich.
Fairbanks, Morse & Co., Chicago, Ill.
Westinghouse, Church, Kerr & Co., Chicago, Ill.
David Bradley Mfg. Co., " "
Chicago Illuminating Co., " "
Sam'l I. Pope & Co., " "
Wells & Newton Co., " "
T. Wilce & Co., " "
Standard Elevator Co., " "
Crane Company, " "
Pneumatic Power & R. R. Gate Co., " "
Western Power & Construction Co., " "
Interior Building Co., " "
Belding Motor & Mfg. Co., " "
Harvey Steel Car Co., " "
Morgan & Wright, " "
Calumet Electric St. Railway Co., " "
Horticultural Building, World's Fair, " "
W. W. Cummer, Cadillac, Mich.,
Cummer & Diggins, Cadillac, Mich.
Cummer Electric Light Co, Cadillac, Mich.
Kentucky Union Land Co., Clay City, Ky.
Wm. Peter, Columbiaville, Mich.
E. A. Kinsey & Co., Cincinnati, Ohio.
L. P. & J. A. Smith, Cleveland, Ohio.
Clare Woodenware Co., Clare, Mich.
J. B. Adams, Duluth, Minn.
Carkin, Stickney & Cram, Detroit, Mich.
R. J. Cram, " "
Gaylord Iron Co., " "
Frontier Iron Works, " "
Ireland & Matthews Mfg. Co. " "
Delta Lumber Co., " "
Masonic Temple, " "
Koppitz-Melchers Brewing Co., Detroit, Mich.
Dayton Water Works, Dayton, Ohio.
Iowa Iron Works, Dubuque, Iowa.
Wagar & Pfeifler, Edmore, Mich.
J. H. Gibbs, Edmore, Mich.
Evart Water Works, Evart Mich.
McDonough Mfg. Co., Eau Claire, Mich.
Fort Bragg Redwood Co., Fort Bragg, Cal.
Hubinger Bros., Frankenmuth, Mich.
J. L. Littlefield, Farwell, Mich.
Thread Milling Co., Flint, Mich.
Oak Grove Asylum, Flint, Mich.
W. A. Patterson, Flint, Mich.
Frankentrost Cheese Co., Frankentrost, Mich.
Wellington Flats, Grand Rapids, Mich.
Grand Rapids Chair Co., " "
New England Furniture Co., " "
Royston Straw Works Co., " "
Kortlander & Murphy Bld'g, " "
Michigan Chair Co., " "
Yawkey & Lee Lumber Co., Hazelhurst, Wis.
C. G. Jewett, Howell, Mich.
Holly Mfg. Co., Holly, Mich.
The Gordon Steam Pump Co., Hamilton, Ohio.
E. C. Hargrave, Hinckley, N. Y.
Central City Soap Co., Jackson, Mich.
Mich. Asylum for the Insane, Kalamazoo, Mich.
Cartier Lumber Co., Ludington, Mich.
Washington Fire Clay Co., Little Falls, Wash.
Eastman, Gardiner & Co., Laurel, Mich.
E. G. Goddard Lumber Co., Logtown, Miss.
Bradley & Ramsey Lumber Co., Lake Charles, La.
P. L. Sherman & Co., Lengsville, Mich.
Samuel Neff, Milwaukee, Wis.
Mann Bros., " "
The Filer & Stowell Co. " "
Wilkins Mfg. Co., " "
Edward P. Allis Co. " "
John Schullte, Manitowoc, Wis.
Ramsey & Jones, Menominee, Wis.
Northern Furnace Co., Marquette, Mich.
H. W. Wilson, Marlette, Mich.
Marlette Milling Co., Marlette, Mich.
Hargrave & Forbes, Mt. Pleasant, Mich.

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The Gorham Brothers Co., Mt. Pleasant, Mich.
N. Holland & Co., Naubinway, Mich.
E. A. Breckenridge, New Orleans, La.
The Cummer Co., Norfolk, Va.
Estey Mfg. Co., Owosso, Mich.
Owosso Water Works, Owosso, Mich.
E. F. Dudley, Owosso, Mich.
Dewey & Stewart, Owosso, Mich.
Gratwick, Smith & Fryer Lumber Co., Otsego Lake, Mich.
J. E. Potts Lumber Co., Ogamaw, Ark.
St. Anthony Lumber Co., Ottawa, Ont.
Pinconning Water Works, Pinconning, Mich.
B. F. Orton, Philadelphia, Pa.
North Pacific Lumber Co., Portland, Ore.
Staver & Walker, Portland, Ore.
The Puget Mill Co., Port Gamble, Wash.
Sibley & Bearinger, Panther, W. Va.
G. B. Hodgman Mfg. Co., Roscommon, Mich.
Henry Munger, Reese, Mich.
T. R. Welch, Reed City, Mich.
Mershon, Brown & Co., Saginaw, Mich.
Stevens & LaDue, " "
O'Donnell, Spencer & Co., " "
Mayflower Mills, " "
Randall & Boyd Lumber Co., " "
R. Diedrich, " "
Bliss & Van Auken, " "
Thos. Cresswell, " "
Mrs. James Hay, " "
Benton Hanchett, " "
Swift Electric Light Co., " "
E. W. Morley, " "
St. Vincent's Orphan Home, " "
S. T. & H. R. R. Co., " "
Steamer Oscoda, " "
A. F. Bartlett & Co., " "
I. Bearinger, " "
Eureka Heat. & Ventilat'g Co., " "
McClellan File Co., " "
St. Mary's Hospital, " "
Saginaw Heating Co., Saginaw, Mich.
Standard Oil Co., " "
Witters' Steam Laundry, " "
J. W. Howry & Sons, " "
Sibley & Bearinger, " "
Saginaw Water Works, West Side Pumping Sta. " "
Wm. Callam & Son, " "
Masonic Temple, " "
Saginaw Manufacturing Co., " "
C. K. Eddy & Sons, " "
Wm. Schuette & Co., " "
National Brewing Co., " "
Saginaw Milling Co., " "
Saginaw Consolidated Street R'y Co., " "
W. B. Mershon & Co., " "
Henry Stephens & Co., St. Helens, Mich.
M. &. M. Tug Line, Seattle, Wash.
Puget Sound Machinery Depot.
Andrew Ittner, Salzburg, Mich.
S. Frost & Co., Staunton, Mich.
Norton-Cook-Pratt Co., San Francisco, Cal.
Saginaw Bay Coal Co., Sebewaing, Mich.
South Bend Electric Co., South Bend, Ind.
Streator Gas & Light Co., Streator, Ill.
Mt. Tacoma Mfg. Co., Tacoma, Wash.
Puget Sound Machine Shop, Tacoma, Wash.
Central Coal & Coke Co., Texarkana, Tex.
Trout Creek Lumber Co., Trout Creek, Mich.
Northern Michigan Asylum, Traverse City, Mich.
Vassar Water Works, Vassar, Mich.
Vassar Milling Co., Vassar, Mich.
M. D. Olds, Vanderbilt, Mich.
Mrs. Biddie Lu Short, Washington. N. C.
Merrill & Ring, West Duluth, Minn.
Moffet, Hodgkins & Clarke, Watertown, N. Y.
American Steel Barge Co., W. Superior, Wis.
W. D. Wing, Wingleton, Mich.
E. S. Fitch Co., West Bay City, Mich.

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LIST OF BOILERS FOR MARINE SERVICE.

BOILERS INSPECTED AND TESTED BY U. S. GOVERNMENT INSPECTORS IN CONFORMANCE WITH RULES AND REGULATIONS RELATING TO MARINE SERVICE. MANUFACTURED BY WICKES BROS.

				Pressure.
Tug Marion, Saginaw	one	4½ ft. x 9 ft.	Marine	
Tug Johnson, Saginaw	one	5 ft. x 9 ft.	Marine	
Steamer Sam'l Neff, Milwaukee	one	8 ft. x 14 ft.	Marine	
Propeller Burkhead, Port Huron	one	11 ft. x 13 ft.	Scotch	
Steamer Hiram W. Sibley	one	13 ft. x 13½ ft.	Scotch	
Carkin, Stickney & Cram	one	7 ft. x 12 ft.	Marine	150
R. J. Cram	one	7 ft. x 12 ft.	Marine	
E. A. Breckenridge, New Orleans	one	7 ft. x 11 ft.	Scotch	
Carkin, Stickney & Cram	one	6½ ft. x 11 ft.	Marine	150
L. P. & J. A. Smith, Cleveland	one	5 ft. x 9 ft.	Marine	
" " " " "	one	4½ ft. x 9 ft.	Marine	
Carkin, Stickney & Cram	one	7 ft. x 12 ft.	Marine	150
L. P. & J. A. Smith, Cleveland	two	6½ ft. x 12 ft.	Marine	150
Puget Mill Co., Seattle	one	5 ft. x 18½ ft.	Marine	
American Steel Barge Co	one	5 ft. x 9 ft.	Marine	
Carkin, Stickney & Cram (Tug Pete Gorman)	one	7½ ft. x 12 ft.	Marine	150
Jas. Reid & Son (Tug A. A. Parker)	one	9 ft. x 14 ft.	Marine	135
Thomas Cresswell (Tug Robt. Boyd)	one	6 ft. x 11 ft.	Marine	150
American Steel Barge Co. (Str. Sam'l Mather)	two	12 ft. x 13 ft.	Scotch	160
Carkin, Stickney & Cram (Tug Carkin)	one	6½ ft. x 11 ft.	Marine	
Poitevant & Favre Lumber Co., Mississippi	one	7 ft. x 11 ft.	Scotch	
M. & M. Tug Line, Seattle	one	6 ft. x 9 ft.	Scotch	
Richard Armstrong (Tug Hay)	one	5½ ft. x 10 ft.	Marine	
American Steel Barge Co., Everett, Wash., (for Str. Everett)	four	11 ft. x 11 ft.	Scotch	160
I. H. Maxim, Washburn, Wis	one	Upright Marine		
Burnside & Burksville Transportation Co., Burnside, Ky., (Str. New Crescent)	one	5 ft. x 12 ft.	Scotch	160
Steamer W. H. Sawyer	one	13 ft. x 13 ft.	Scotch	160
Steamer Edward Smith	one	13 ft. x 13 ft.	Scotch	160
Steamer Emily P. Weed	three	11½ ft. x 12 ft.	Scotch	160
Steamer C. H. Bradley	two	11½ ft. x 12 ft.	Scotch	160
Steamer Mackinaw	two	13¼ ft. x 13 ft.	Scotch	160
Steamer Keewanaw	two	13⅓ ft. x 13 ft.	Scotch	160
Steamer F. & P. M. No. 5	two	11½ ft. x 12 ft.	Scotch	160
Steamer W. F. Sauber	one	13 ft. x 13 ft.	Scotch	160
Ocean Tug Yulu	one	8 ft. x 14 ft.	Marine	
U. S. Government Ocean Lightship No. 51	two	8 ft. x 9 ft.	Scotch	160
U. S. Government Ocean Lightship No. 52	two	8 ft. x 9 ft.	Scotch	160
U. S. Government Ocean Lightship No. 53	two	8 ft. x 9 ft.	Scotch	160
U. S. Government Ocean Lightship No. 54	two	8 ft. x 9 ft.	Scotch	160
Steamer Uganda	two	11½ ft. x 12 ft.	Scotch	160
Steamer W. H. Gilbert	three	12 ft. x 12 ft.	Scotch	165
Steamer C. F. Behlman	two	11½ ft. x 12 ft.	Scotch	160

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					Pressure.
Steamer Ossifrage	one	12 ft. x 12	ft., Scotch	..	160
Steamer Merida	three	12½ ft. x 12	ft., Scotch	..	170
Steamer S. S. Curry	three	12½ ft. x 12	ft., Scotch	..	170
Ocean Tug W. G. Wilmot, New Orleans	one	12½ ft. x 12	ft., Scotch	..	160
Steamer W. H. Gratwick	two	13 ft. x 12	ft., Scotch	..	170
Steamer L. R. Doty	two	12½ ft. x 12	ft., Scotch	..	170
Steamer Centurion	three	12½ ft. x 12	ft., Scotch	..	170
Steamer George Stone	two	11 ft. x 12	ft., Scotch	..	170
American Steel Barge Co	two	14 ft. x 15	ft., Loco. Ma.		
American Steel Barge Co. (Steamer No. 137)	two	12 ft. x 13	ft., Scotch	..	160
Boutell & Smith (Tug Sweepstakes)	one	13 ft. x 13	ft., Scotch	..	130
E. M. Short, Washington, N. C.	one	5 ft. x 7	ft., Marine	.	100
Corning Transportation Co., Saginaw, (Str. Oscoda)	one	12 ft. x 13	ft., Scotch	..	130
Corning Transportation Co., Saginaw, (Str. C. H. Green)	one	13 ft. x 13	ft., Scotch	..	125
M. & M. Tug Line, Seattle, Wash. (Str. Magic)	one	8 ft. x 11	ft., Scotch	..	140
U. S. Government (Revenue Cutter Wm. Windom)	one	12 ft. x 16	ft., Dbl. End. Scotch.		165
Str. Minnie E. Kelton	one	10½ ft. x 12	ft., Scotch	..	135
Steamer Madagascar	one	12½ ft. x 12	ft., Scotch	..	165
Steamer Nicaragua	one	12½ ft. x 12	ft., Scotch	..	165
Steamer Shenandoah	two	13 ft. x 13	ft., Scotch	..	170
Mitchell Transpor'tn Co., Cleveland (John K. McWilliams)	two	13½ ft. x 12	ft., Scotch	..	170
Eddy Transportation Co., Bay City	two	13¾ ft. x 12	ft., Scotch	..	170
James Davidson (Rappahannock)	two	12¼ ft. x 12	ft., Scotch	..	170
James Davidson (Sacramento)	two	12¼ ft. x 12	ft., Scotch	..	170
Detroit, Belle Isle & Windsor Ferry Co. (Str. Pleasure)	two	10 ft. x 12	ft., Scotch	..	130

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APPENDIX.

MACHINE DEPARTMENT,

IN BRIEF.

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MACHINE DEPARTMENT.

WE present here, very briefly, as an appendix to our boiler catalogue, a few of the most noteworthy machine specialties which we manufacture largely. Some of these machines are directly applicable to boiler work, and, we believe, will be of interest generally to those investigating boilers, as well as those searching for a modern boiler shop equipment, in whose special interest we have presented this matter, and whom we invite to give their most thorough inspection.

The Wickes Gang Saw Mill, which has become celebrated in the saw mill trade, we present in order to give the uninitiated some idea of the progress that has been made in saw mill work, as well as being indicative, in a measure, of the size of our machine shop and the character of our work. To those interested in the saw mill machinery we would be pleased to send our special catalogue of this department, upon application.

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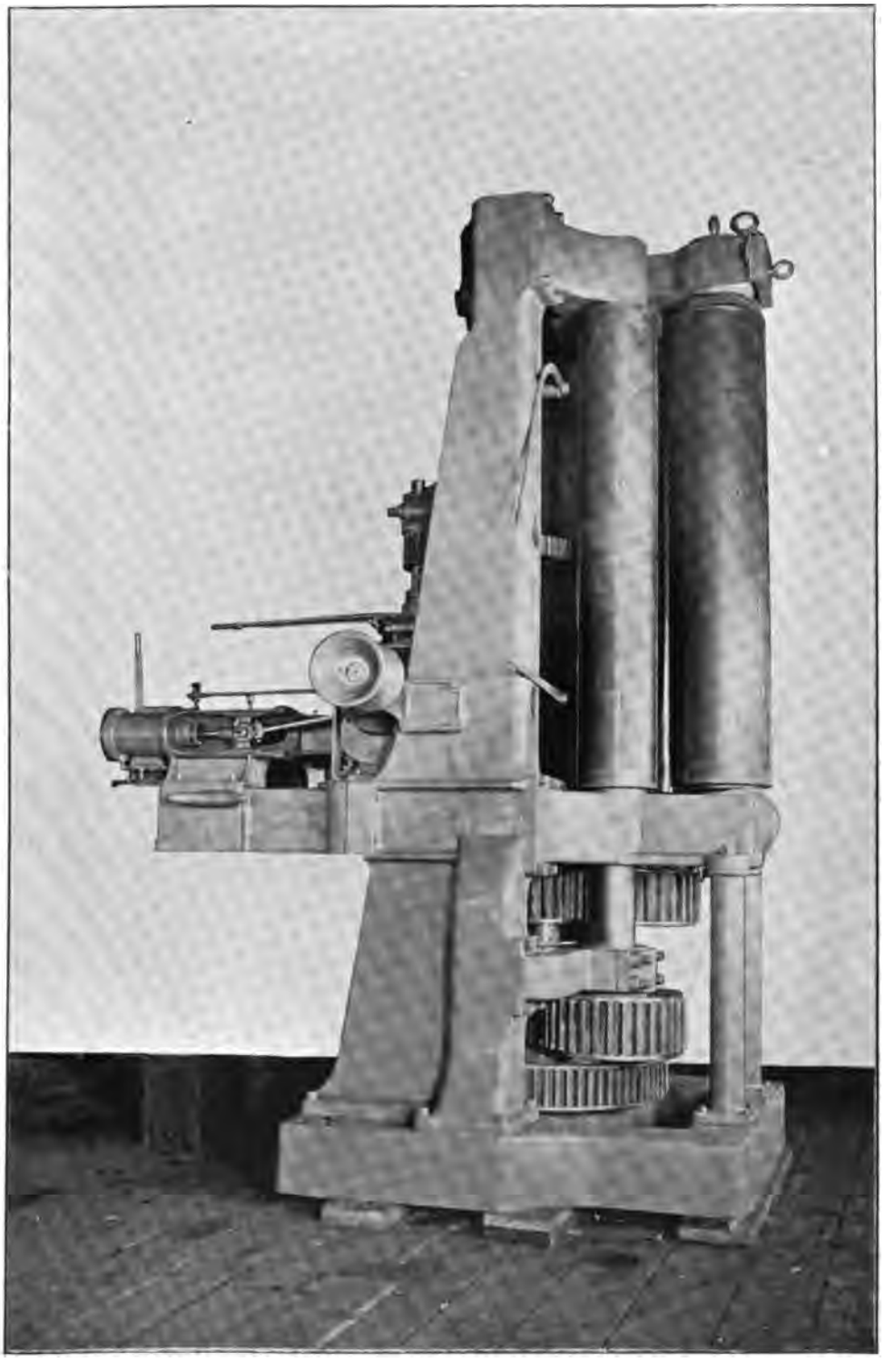
The cut below represents the roll shown on following page, being a front perspective view, showing the rolls, together with the gearing, the great strength of which is at once apparent, while the following cut is a perspective view of the rear, showing the engine, from which the roll receives its power.



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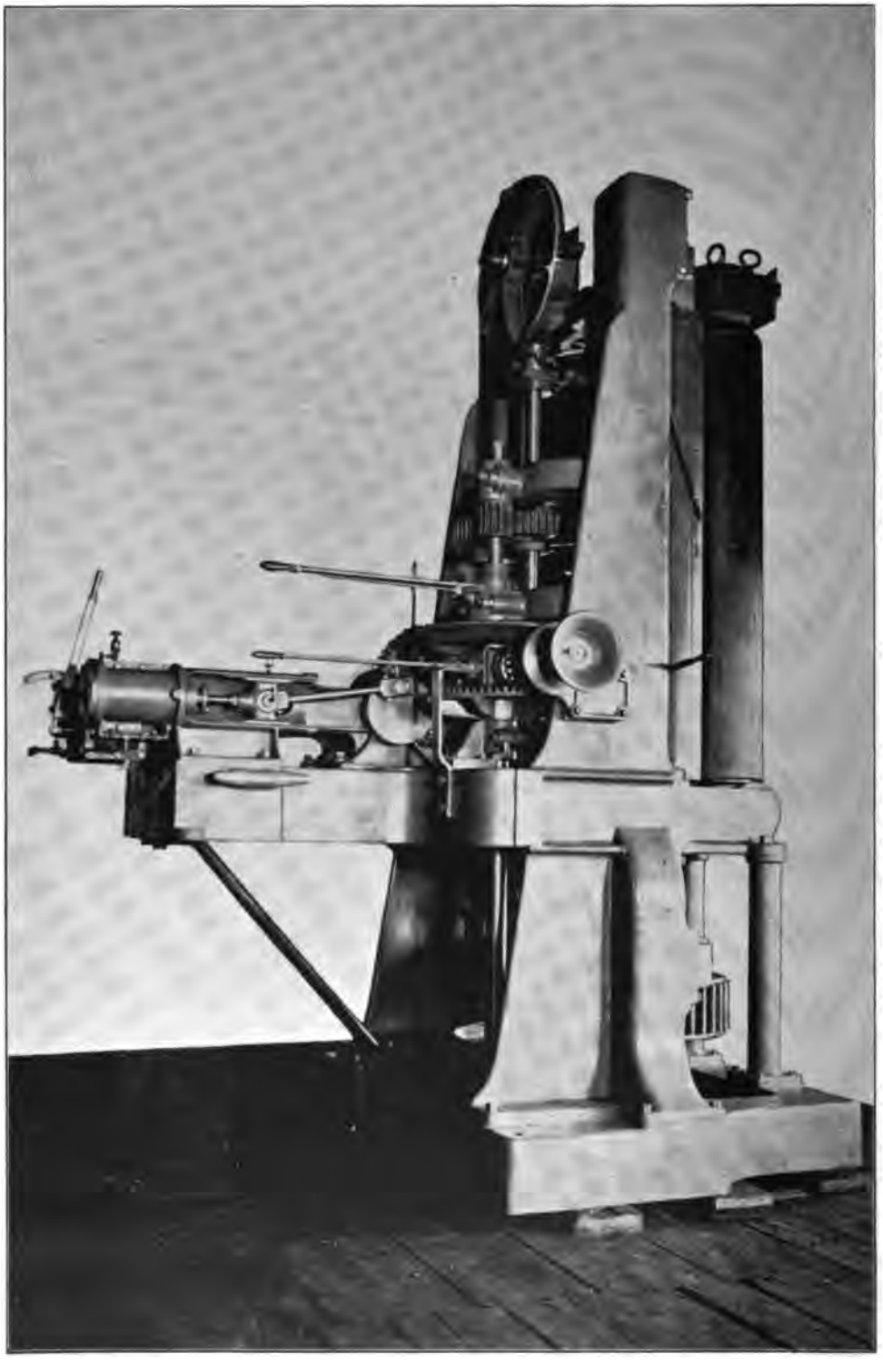
The vertical roll shown in cut is designed for plates up to 1¾-inch in thickness, and are especially desirable for heavy plates, as the plate standing on its edge admits of rolling to a more perfect circle, and is handled much easier than is possible to handle extremely heavy plates through the horizontal rolls.



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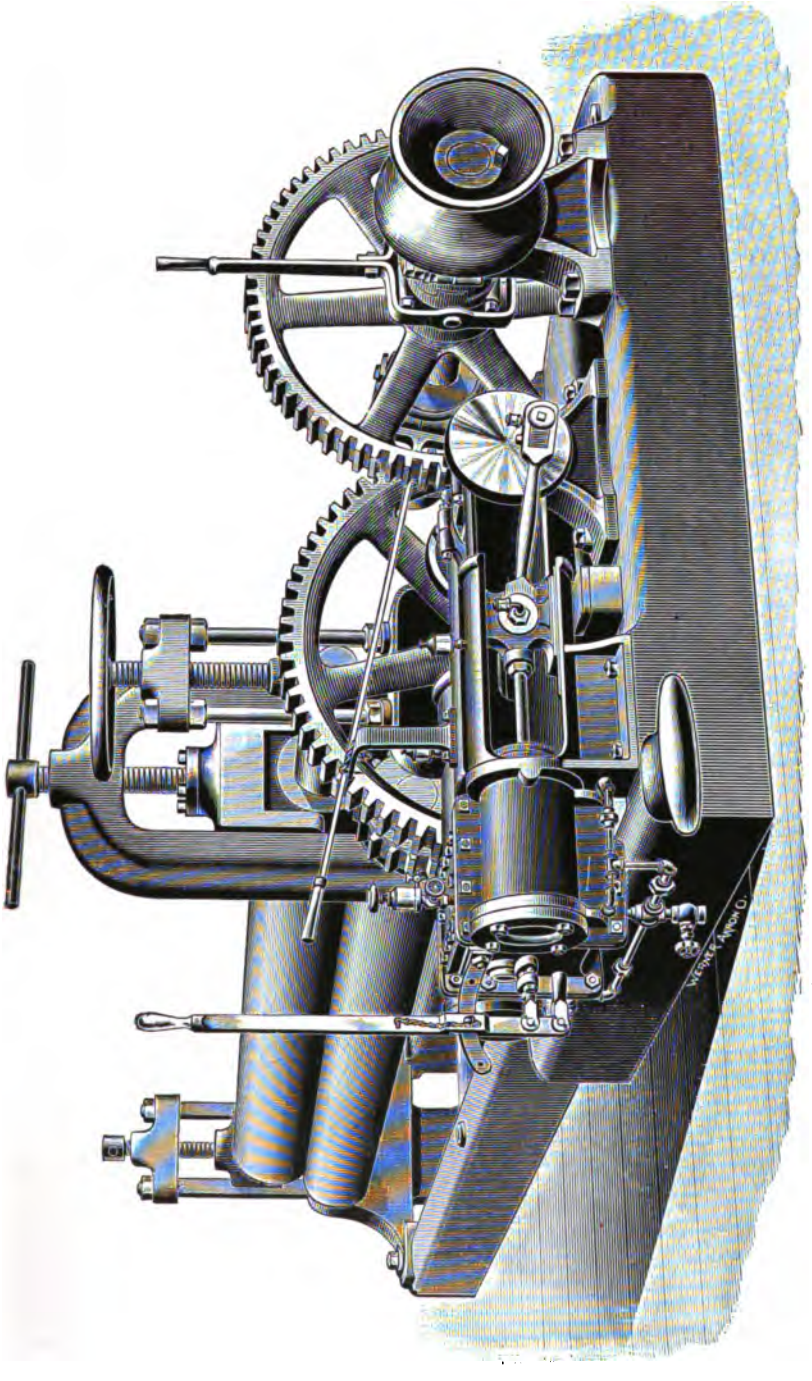

The above cut represents our power-driven rolls from 8 to 14 feet in length between housings. Top roll is raised and lowered by hand-power screws, and has supported extension and outboard bearing hinged for taking out a full course. It is a very powerful and satisfactory machine for the lighter class of work.

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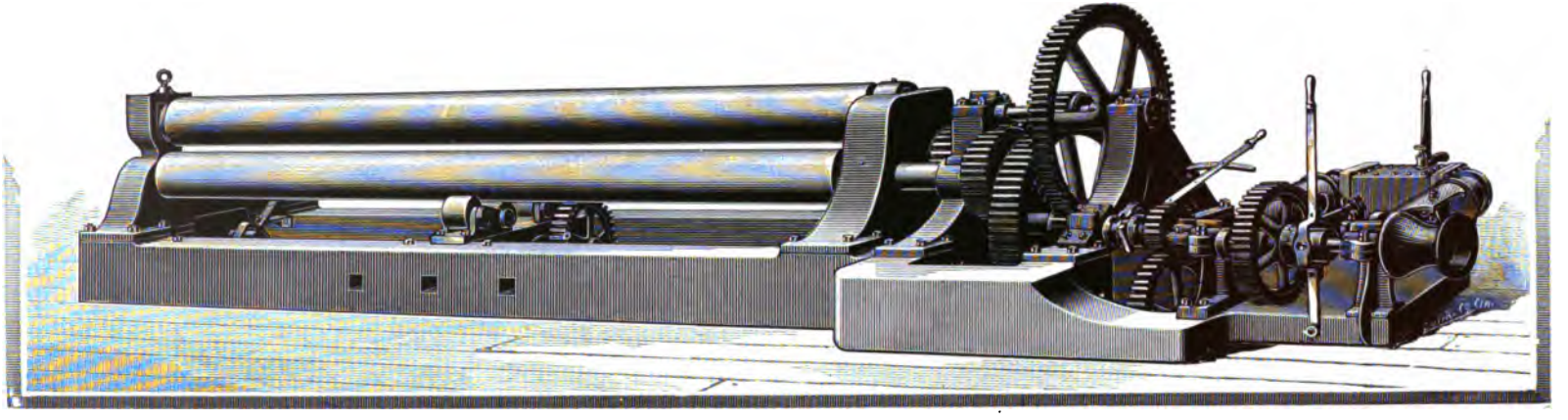

The above cut represents the style of rolls as built from 10 to 30 feet in length between housings, and for different thicknesses of plate up to 1¼ inch in thickness. The housings are offset so as to admit the use of driving gears of large diameters; the top roll is raised and lowered by power, being operated by a patent friction device that prevents breaking of gears should rolls be brought together. A clutch device is attached to each end of top roll, which admits of raising or lowering either end independently. The engines are handled entirely by one lever, which enables the operator to easily oversee the work.

USERS OF ROLLS.

Wm. B. Pollock & Co.	Youngstown, Ohio.
Arthur Sewall & Co.	Bath, Maine.
Fraser & Chalmers	Chicago, Ill.
Ames Iron Works	Oswego, N. Y.
Erie City Iron Works	Erie, Pa.
T. M. Nagle	Erie, Pa.
Dry Dock Engine Works	Detroit, Mich.
The Brownell & Co.	Dayton, Ohio.
Enterprise Boiler Co.	Youngstown, Ohio.
American Steel Barge Co. (2)	West Superior, Wis.
Pacific Steel Barge Co.	Everett, Wash.
Coatesville Boiler Works	Coatesville, Pa.
The J. C. McNeil Co.	Akron, Ohio.
Richard Garstang (Rohan Bros.)	St. Louis, Mo.
Murray Iron Works Co.	Burlington, Iowa.
Grant Locomotive Works	Chicago, Ill.
Haxtun Steam Heater Co.	Kenawee, Ill.
Heggie Bros.	Joliet, Ill.
Phœnix Manufacturing Co.	Duluth, Minn.
Daniel B. Edwards	New Orleans, La.
Kenny Bros.	St. Paul, Minn.

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PORTABLE HYDRAULIC RIVETER.

The main body of this Riveter and cylinder are made of steel, and cast in one piece, and carry the lower die for holding or forming one head of the rivet. The second, or upper, die is carried in a steel arm that is journaled at one end in such a manner that the die surfaces will be parallel to each other when forming the rivet. The cylinder is set back and at an angle to the center line of dies. This exposes the parts holding the dies the greatest amount possible, and admits of riveting a great variety of work. This plan also presses the arm down almost in a straight line, and prevents any side pressure on the piston. The valves are so constructed that they will guide the water under pressure to the top of the piston and force the piston down. When reversing the valve lever the water from the top of the piston will be discharged, and the pressure applied underneath the piston, the piston will rise and the water above the piston will be at the same time discharged. The machine is swiveled at the back and revolved with a worm wheel

for bringing the riveter in the different positions required. The main arm is also made of steel, and is also swiveled at the top in such shape as to leave the upper parts exposed for forming one of the universal joints for pipe connections. The riveter is connected by means of pipes and universal joints, for the purpose of moving it about in any direction or position. The universal joints consist of two stuffing boxes, in which revolve pipes with collars, one collar deing seated in the gland so as to prevent the pipe from being pushed out by the water pressure on the end of the pipe. The universal joints are easily packed, and oil can be applied on all wearing surfaces. This riveter is constructed entirely of steel and bronze, and is especially designed for use in riveting heavy plates where it is not convenient to transfer such heavy work to a stationary machine. In shops where hydraulic plants are already installed the same power can be used for operating this machine.

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TO MILL MEN AND MANUFACTURERS OF LUMBER:

We ask your attention to our last improved Iron Frame Gang Mill. The accompanying cuts represent some of the different styles of machines that we manufacture. They are constructed to be driven by belt, friction, or direct engine, as desired. The important requisite in this class of mills is such designs and proportion of parts as will insure durability and continued movement at the highest speed, safely increasing the quantity, and improving the quality of work done, and admitting the use of thinner saws and still carry heavier feed than is practical in the slower moving sash. These are among the many advantages gained in the Iron Frame Machine.

Many improvements have been made in the mechanism of oscillation, and from these we have secured the patents and are sole manufacturers of the latest and best designs in the market. This movement, when properly adjusted, gives a perfect clearance and the easiest cut of saw yet obtained. It adds no extra weight to the sash, and avoids the cumbrous rock-shaft and its attendant joints, usually attached to sash, and weighing from three to five hundred pounds, which has been found so objectionable in many other movements. The feed is continuous, and is made variable from one-quarter to one and one-quarter inch to each stroke, controllable by the sawyer. Power is applied to the press rolls in all of the different styles of machines, and, when desired, press rolls are made variable to cut cants of different thicknesses side by side at the same time. A special feature of this machine is the spreading of the lower frame, so that its base rests upon an independent portion of the foundation from the main pillow-block or crank-shaft. The solidity of the whole structure is thus increased, both by the increased width at the base and the prevention of connecting vibrations, which necessarily must communicate when resting upon the same part, as in other forms of such machines heretofore in use.

Our No. 1 Gangs represent the larger class of mills, and are made with sash or gate 36 to 60 inches in width, and with 9, 10 and 11-inch shafts. Our medium size of Gang Mill, shown in cut No. 2, has 9-inch forged shaft, main pillow-block has a base of 6½ feet by 21-inch bearing; weight, 2,800 pounds. The cap is secured by two forged bolts 3½ inches diameter, and by this arrangement no unequal strain upon the cap is possible. A disc crank is used with suitable counterbalance, expressly adapted to the weight and speed of sash; a hammered steel wrist-pin 5½ inches in diameter, and a forged pitman of the most approved pattern, with best composition boxes. The iron drive-pulley is 4 to 4½ feet in diameter, and 24 inches face. The fly-wheel 6 feet in diameter, weighing 4,700 pounds, turned off at rim. When a wider and heavier sash is required a proportionate increase is made in all these parts. Speed for this size mill, about 225 strokes per minute.

In the construction of the sash the stiles are made of steel; the lower girt and upper heads are made in one solid piece, without rivets, giving the greatest strength possible, with the least weight. The outfit also includes eight iron rollers for the floor, 8½ inches in diameter, with iron stands for all, four in front of machine and four in rear of it. Two or three rolls in each set are provided with gearing to carry cants into the machine and lumber away from it, by power worked by friction. Also a full set of Lippencott's steel saw hangings and gauges for one-inch lumber. The weight of this machine as described is 21½ tons. They are, however, built in larger and smaller sizes, adapted to any locality, quality or quantity of work desired.

In construction the machines are erected upon an iron foundation, complete, at our works, so that every part is fitted to its proper place before shipment. Machines are made right or left hand to suit any position in mill.

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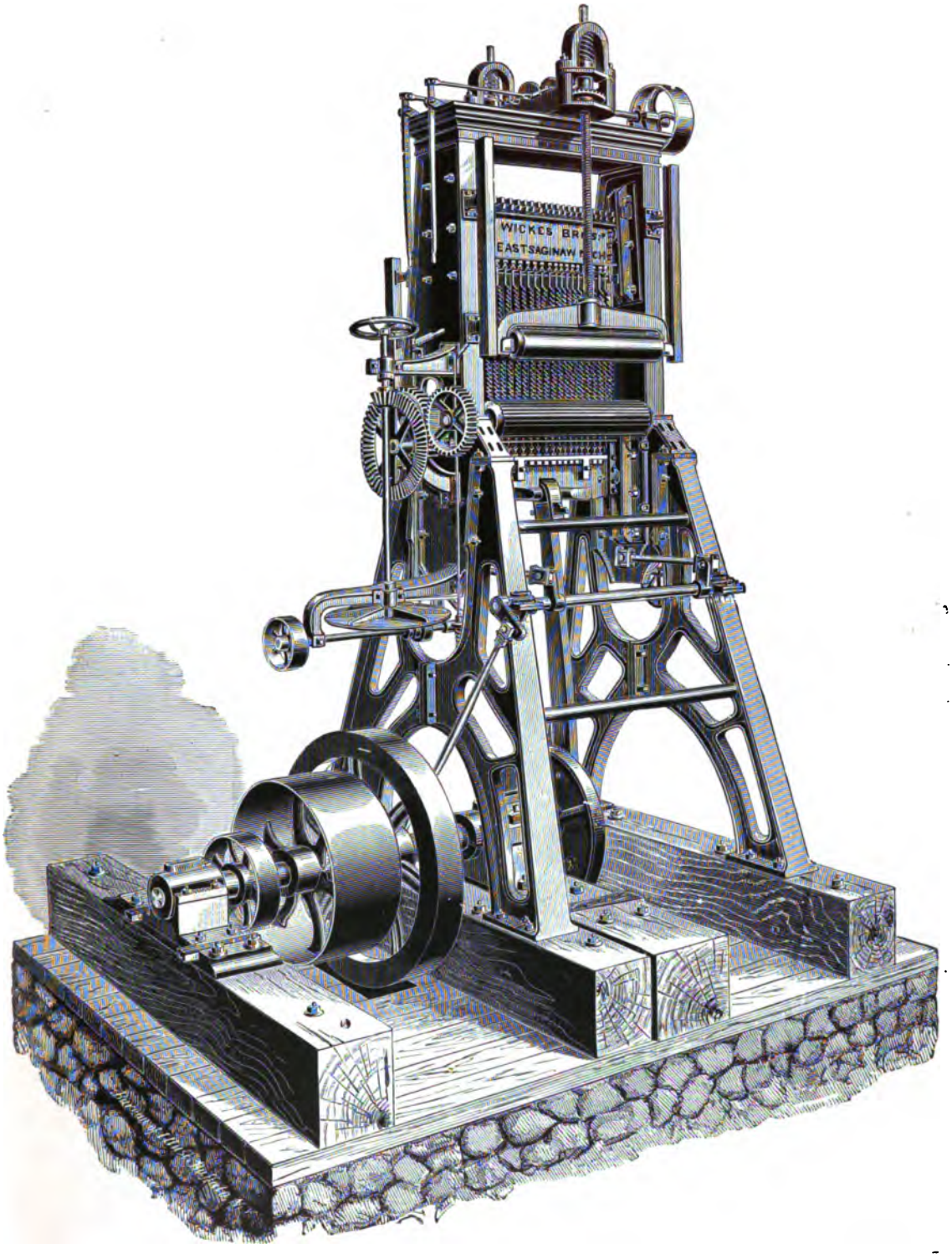
NO. 2 GANG MILL.



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STEAM GANG MILL.

This machine, shown in accompanying cut, embodies all the essential features and well-tried proportions so successfully used in the No. 3 belt gang mills for several years. The growing demand or want of this style of mill comes largely from the southern states, where many mills contain but one cutting machine (a circular or band mill), and each of these manufacturers often require considerable rift flooring and other kinds of inch lumber as a part of their product. To produce this class of lumber in perfect thicknesses with the least possible expense and loss of timber by a saw kerf reduced to one-eight inch, the gang mill has the universal verdict of many hundred users as the most suitable and economical machine. The introduction of a belt gang to the average circular or band mill plant, where no surplus power is at hand, has been attended with considerable expense, the room oftentimes being limited, etc. These reasons have prompted us to introduce the independent steam gang here illustrated. Supplying its own power, occupying little room, simple and strong in construction, easily and cheaply set in position, very easily operated, and so designed and proportioned as to avoid all detention and delays while in use, it embodies many years of durable and constant service, with the least possible cost to operate. This machine will undoubtedly commend itself to the favorable judgment of all manufacturers for any kind of timber and quantity of lumber required.

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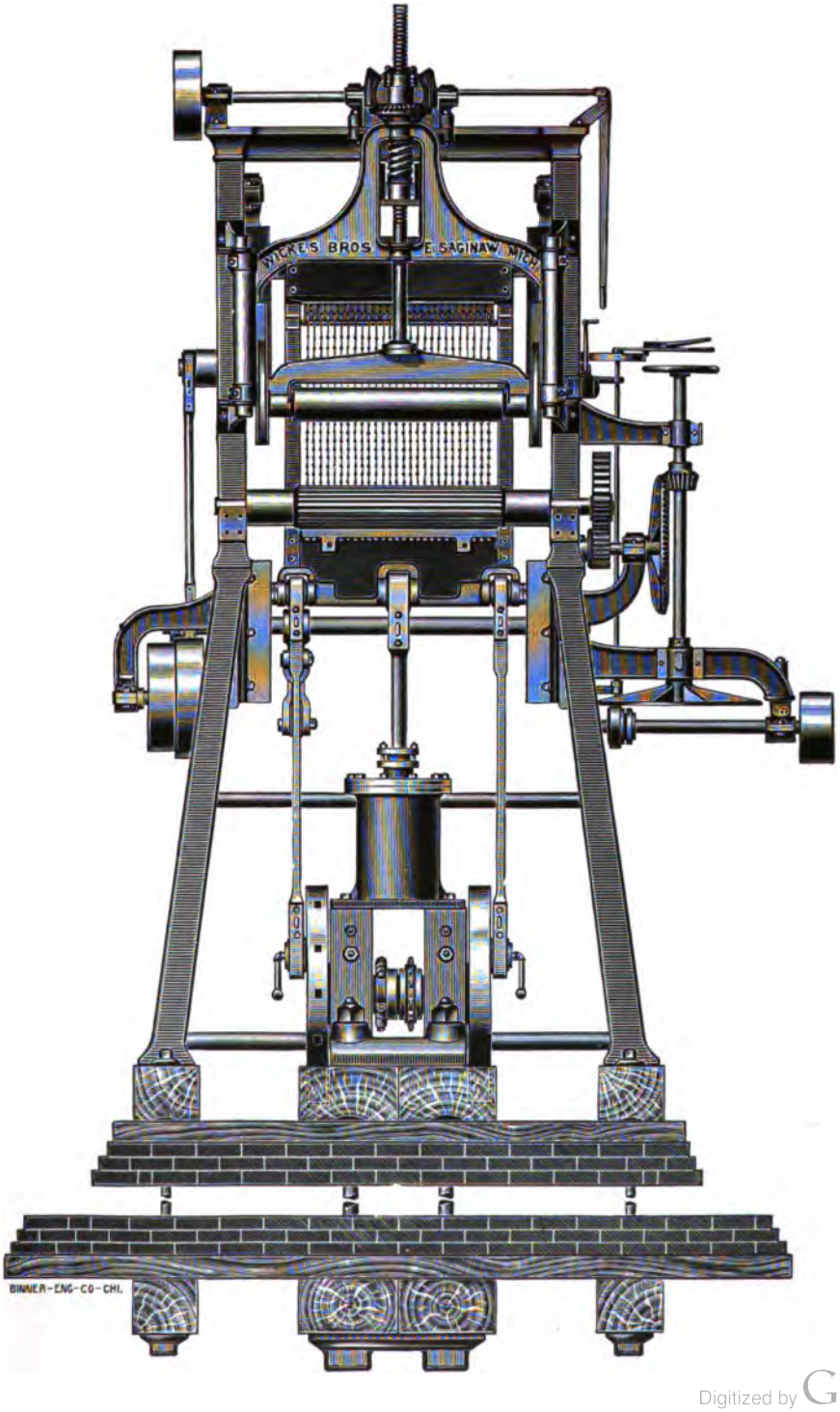
STEAM GANG MILL.



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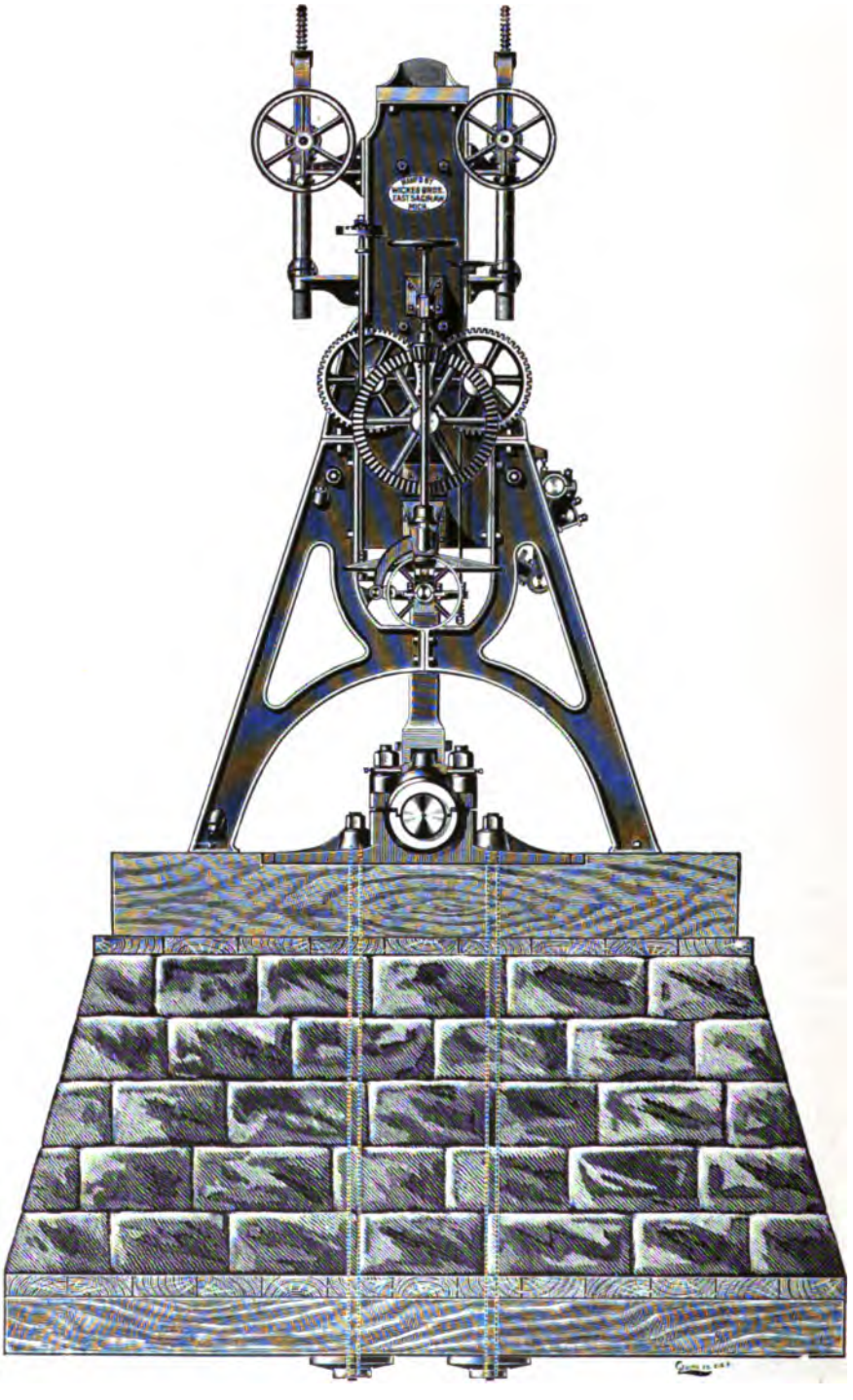
NO. 3 GANG MILL.



SIDE VIEW.

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THE NO. 3 GANG MILL.

We call your special attention to the accompanying cuts of a No. 3 new design and smaller complete Iron Frame Gang Mill, intended for a sash from 26 to 36 inches wide and for saws 36 inches long, to cut cants from 8 to 14 inches in depth. The main or valuable features of this machine are: *First*, simplicity; *Second*, strength of parts, insuring durability; *Third*, the most simple and effective oscillating movement, which presents saws to the timber in such a manner as to cut under or against the grain during the entire half stroke, at same time giving a perfect working in the up stroke, producing the easiest possible cut of saws, admitting the use of the thinnest blades with success; this plan also does away with all eccentric and crank motion to operate it, greatly reducing friction and wearing parts without adding any extra weight to sash. The main shaft is 8 inches in diameter, with crank and pin all forged in one piece, giving the greatest strength possible, with a stroke of 14 inches. The main pillow-block is especially strong and heavy; the main pitman of new design, of the greatest strength possible, and adapted to high speeds with safety. The feed works are of the same general style and excellence as in the larger machines.

Power is applied to the press rolls in the most complete form when required, though not shown in cuts. The frame work or bales containing press rolls are arranged upon hinges, so as to swing out and away from the saws, so that the work of hanging in saws is entirely unobstructed. There is also furnished with this machine eight iron floor rolls and stands, made to operate by power when desired; also saw hangings of the best known form, and gauges for one-inch lumber. This mill is especially suited for cutting rift-sawed flooring from the southern pine, as well as boards and all work required of a gang mill working either in connection with a band mill or circular saw. In designing this mill we have adhered to all former experience in proportioning its parts and choice of material, and no portion so far departed from well-tested principles as to place before our patrons this machine as an experiment, but have followed in the line of our former well-known gangs, which are now almost universally used in the saw mills of a larger class. We furnish blue-prints of both foundation plans and elevation, with all measurements necessary for their erection. Machines are made right or left hand, to suit any position in the mill.

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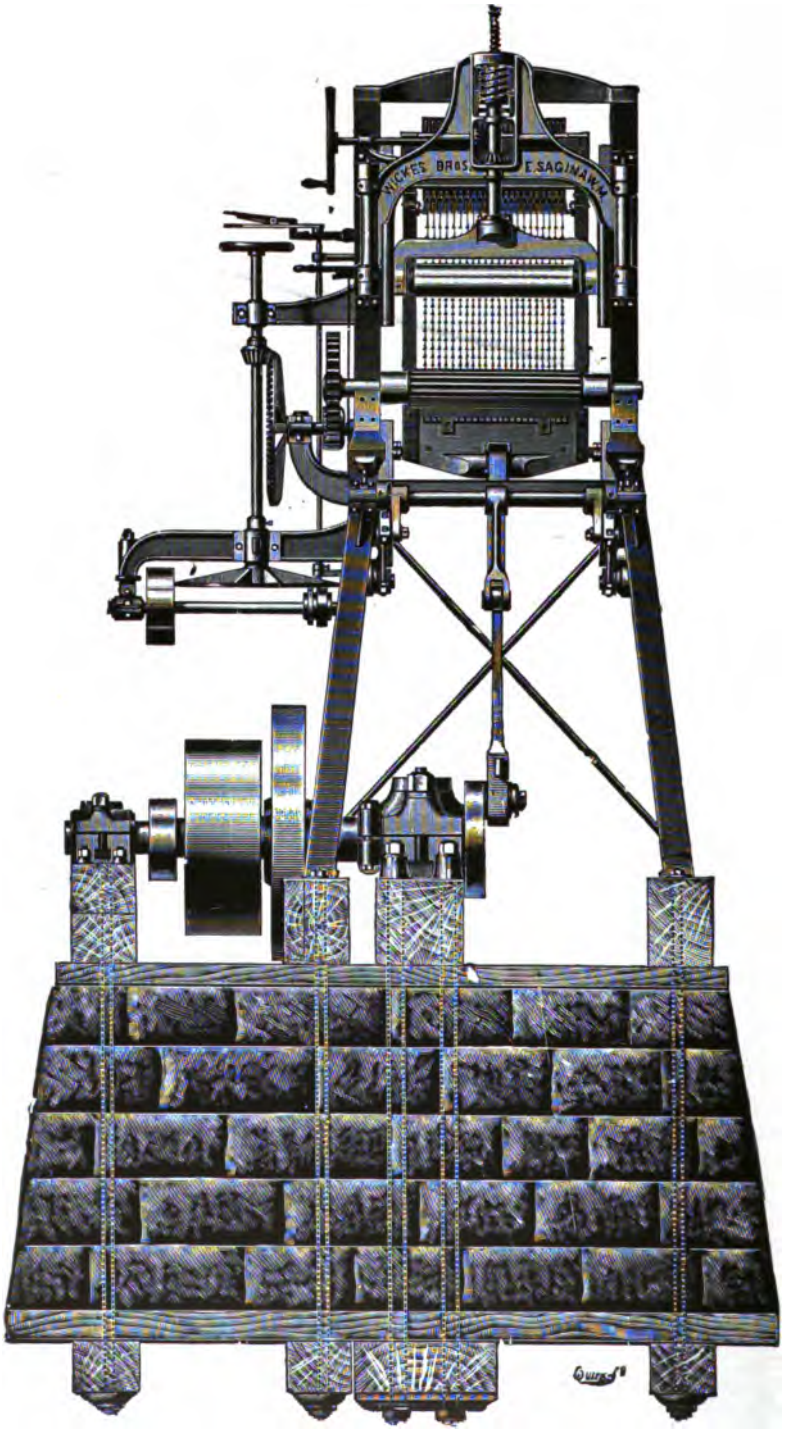
NO. 3 GANG MILL.



FRONT VIEW.

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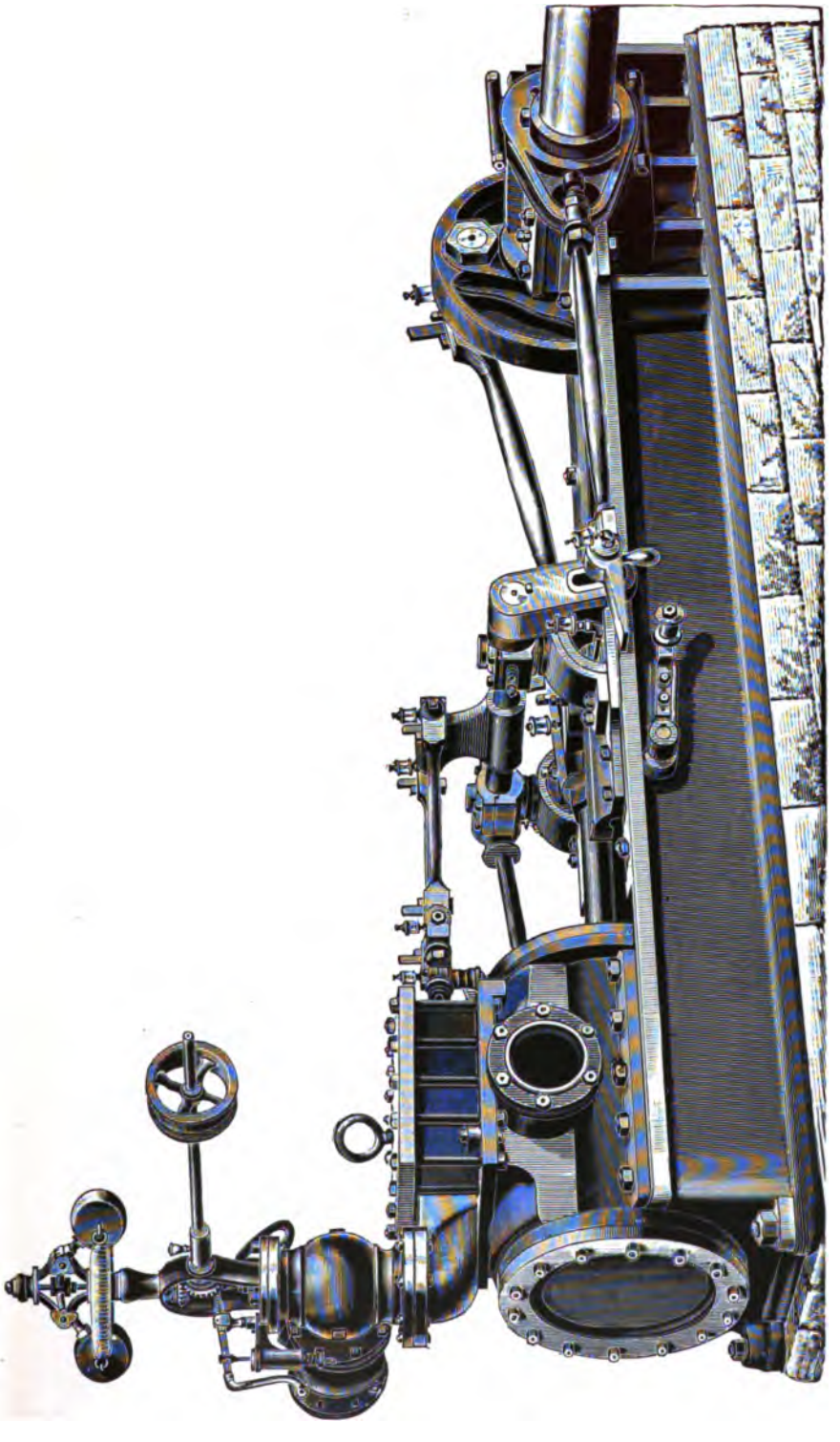

The above cut represents our heavy-duty engine, especially designed for saw mill use, and is made in the following sizes of cylinder: 16 x 20, 18 x 22, 20 x 24, 22 x 26, 22 x 30, 24 x 32, 26 x 32, 28 x 36, 30 x 36, 32 x 42, and 34 x 42.

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